Models with four powertrains have one or two outputs. Double-output models exhibit individual control of each output.

The input voltage is fed via fuse, filter, and rectifier to the powertrains with main transformers designed in planar technique. The input filter with very small input capacitance generates virtually no inrush current. An input transient suppressor protects the converter against high voltage peaks and surges. Input over- and undervoltage lockout as well as input current limitation protect the converter from operation outside of its specification. The input voltage waveform is sensed by the primary control logic to allow active power factor correction, forcing the input current to follow the input voltage waveform.

The secondary side of each main transformer supplies via the rectifier diode a large electrolytic output storage capacitor providing for the hold-up time. Double-output models exhibit an individual control logic for each output. The output voltage and the output current are measured and fed back to the primary control logic via an optocoupler. A second control loop monitors the output voltage. It disables the output in the case of a failure in the control logic and limits the output voltage.

Built-in temperature sensors monitor the internal temperature of each powertrain. If the temperature exceeds the limit, the converter reduces the output power continuously to keep the temperature below its limit. A green LED on the front cover confirms the presence of the output voltage(s).

The R input (option R, M1, or M2) allows for external adjustment of the output voltage by means of a resistor or an external voltage source. An external sensor can be connected to the R input and allows for temperature-controlled battery charging; see *Accessories*.

Electrical Input Data

General conditions:
T_A = 25 °C, unless T_C is specified.

Table 3: Input data LW models

Input			LXR						LXN						Unit
			AC-Input			DC-Input			AC-Input			DC-Input			
Characteristic		Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	
V_i	Operating input voltage range	I_o = 0 – $I_{o\,nom}$ T_c – $T_{c\,max}$	85 [2]		264	90 [2]		350 [3]	85 [2]		264	90 [2]		350 [3]	V
$V_{i\,nom}$	Rated input volt. range		100	(230)	240		220		100	(230)	240		220		
f_i	Rated input frequency [1]			50 – 60			--			50 – 60			--		Hz
I_i	Input current	$I_{o\,nom}$, V_i = $V_{i\,nom}$ $I_{o\,nom}$, V_i = $V_{i\,min}$		1.9 5.2			1.95 5.0			2.6 7.0			2.6 6.6		A
P_{i0}	No-load input power	$V_{i\,min}$ – $V_{i\,max}$		3			3			3			3		W
I_{inrush}	Inrush current	$V_{i\,max}$, t > 0.1 ms		5			5			5			5		A
C_i	Input capacitance			5			5			6			6		µF
PF	Power factor	$V_{i\,nom}$ = 230 V, $I_{o\,nom}$	0.90				--		0.90				--		
$V_{i\,RFI}$	Conducted input RFI	EN 55011/55022 $V_{i\,nom}$, $I_{o\,nom}$		A			A			A			A		
	Radiated input RFI														
f_{switch}	Switching frequency			130			130			130			130		kHz

1 For operating frequencies <47 Hz and >63 Hz contact the factory. The converters have been tested up to 440 Hz.
2 Output power derating at low input voltage and/or high case temperature T_C; see *Output Power Derating*.
3 V_i ≤ 250 VDC for models with option F.

Power Factor, Harmonics

All converters feature active power factor correction.

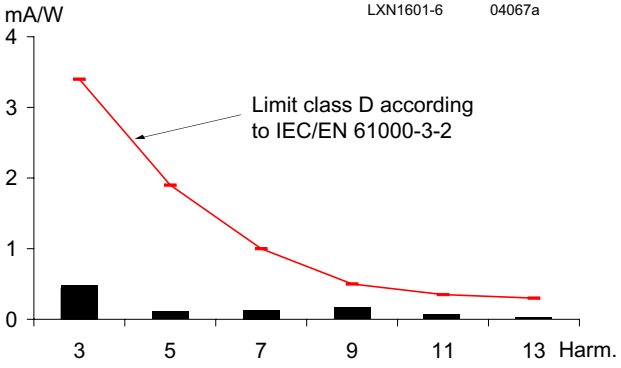

Fig. 4
Harmonic currents at input current, measured at V_i = 230 VAC, $I_o = I_{o\,nom}$ (LXN1601-6)

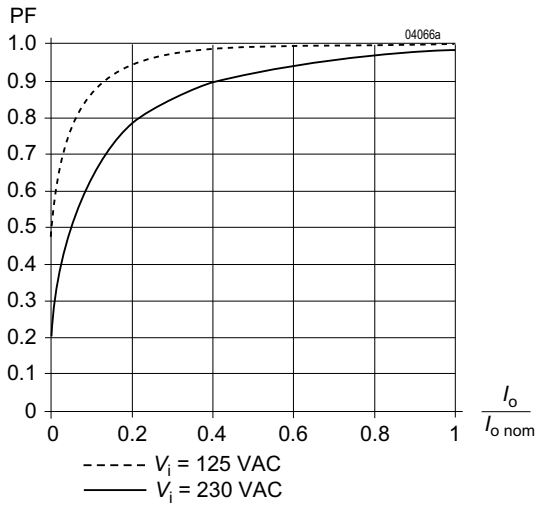

Fig. 5
Power factor versus load

Electrical Output Data

Table 6a: Output data of 375 Watt standard models. General conditions: T_A = 25 °C, unless T_A is specified; R input open-circuit

Model			LXR1601			LXR1701			LXR1801			Unit
Characteristic		Conditions	min	typ	max	min	typ	max	min	typ	max	
$V_{o\,nom}$	Output voltage nominal [1]	$V_{i\,nom}$, $I_{o\,nom}$	24.25	24.7	25.2	36.4	37	37.8	48.5	49.36	50.4	V
		*	24.55	24.7	24.85	36.8	37	37.2	49.06	49.36	49.66	
$V_{o\,worst}$	Output voltage range of tolerance	$V_{i\,min} - V_{i\,max}$, $I_o = (0.1 - 1)\ I_{o\,nom}$	24.0		25.8	36.0		38.7	48.0		51.6	
$V_{o\,L}$	Overvoltage protection		28.5		30	42.7		45	57		60	
$P_{o\,nom}$	Output power nominal	V_i = 100 VAC – $V_{i\,max}$		371			370			371		W
$I_{o\,nom}$	Output current nominal	V_i = 100 VAC – $V_{i\,max}$		15			10			7.5		A
$I_{o\,L}$	Output current limit [3]	V_i = 100 VAC – $V_{i\,max}$	15.1		17.2	10.2		11.4	7.65		8.7	
I_{op}	Output current boost [4]	typ. 1 s		22.5			15			11.3		
v_o	Ripple and noise	V_i = 230 VAC, f_i = 50 Hz, $I_{o\,nom}$		100			100			100		mV_{pp}
				1100 [2]			1200 [2]			1200 [2]		
$\Delta V_{o\,u}$	Static line regulation	100 VAC – $V_{i\,max}$, $I_{o\,nom}$		±0.1			±0.15			±0.15		V
$\Delta V_{o\,l}$	Static load regulation (droop)	$V_{i\,nom}$, $I_o = (0.1 - 1)\ I_{o\,nom}$		– 0.4			– 0.6			– 0.8		
v_{od}	Dynamic load regulation Voltage deviation and recovery time	$V_{i\,nom}$, $I_o = (0.5 \leftrightarrow 1)\ I_{o\,nom}$		±1.2			±1.5			±1.8		
				40			80			80		ms
αv_o	Temperature coefficient	$T_{C\,min} - T_{C\,max}$		±0.02			±0.02			±0.02		%/K
t_{or}	Start-up time	$V_i = 0 \rightarrow V_{i\,nom}$, $I_{o\,nom}$		700			700			700		ms
$t_{oh\,min}$	Hold-up time	$I_{o\,nom}$, $V_{o\,nom} \rightarrow 0.8\ V_{o\,nom}$		15			20			25		

* Converters with version V105 or higher
[1] Setting voltage with open R-input
[2] Superimposed low frequency ripple at 2 • f_i
[3] Rectangular current limit characteristic (continuous operation)
[4] Short-term peak power capability 150% of $P_{o\,nom}$ for approx. 1 s

Electromagnetic Compatibility (EMC)

Electromagnetic Immunity

The X Series has been successfully tested to the following specifications:

Table 8: Electromagnetic immunity (type tests)

Phenomenon	Standard	Level	Coupling mode [1]	Value applied	Waveform	Source imped.	Test procedure	In oper.	Perf. crit.[2]
Electrostatic discharge (to case)	IEC/EN 61000-4-2	4 [3]	contact discharge	8000 V_p	1/50 ns	330 Ω, 150 pF	10 positive and 10 negative discharges	yes	A
			air discharge	15000 V_p					
Electromagnetic field	IEC/EN 61000-4-3	x [4]	antenna	20 V/m	AM 80%/1 kHz	n.a.	80 – 800 MHz	yes	A
		[5]	antenna	20 V/m 10 V/m 5 V/m 3 V/m	AM 80%/1 kHz	n.a.	800 – 1000 MHz 1400 – 2000 MHz 2000 – 2700 MHz 5100 – 6000 MHz	yes	A
Electrical fast transients/burst	IEC/EN 61000-4-4	3 [6]	capacitive, o/c	±2000 V_p	bursts of 5/50 ns 2.5/5 kHz over 15 ms; burst period: 300 ms	50 Ω	60 s positive 60 s negative transients per coupling mode	yes	A
		4	±i/c, +i/–i direct	±4000 V_p					
Surges	IEC/EN 61000-4-5	3 [7]	±i/c	±2000 V_p	1.2/50 µs	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	B
		2 [7]	+i/–i	±1000 V_p	1.2/50 µs	2 Ω			
Conducted disturbances	IEC/EN 61000-4-6	3 [8]	i, o, signal wires	10 VAC	AM 80% (140 dBµV)	150 Ω	0.15 – 80 MHz pulses	yes	A
Power frequency magnetic field	IEC/EN 61000-4-8	[9]	--	100 A/m	50 and 60 Hz	--	x, y, and z axis	yes	A

1 i = input, o = output, c = case.
2 A = Normal operation, no deviation from specs; B = Normal operation, temporary loss of function or deviation from specs. possible
3 Exceeds EN 50121-3-2:2016 table 5.3 and EN 50121-4:2016 table 2.4.
4 Corresponds to EN 50121-3-2:2016 table 5.1 and EN 50121-4:2016 table 2.1.
5 Complies with EN 50121-3-2:2016 table 5.2 and EN 50121-4:2016 table 2.2.
6 Complies with EN 50121-3-2:2016 table 3.2 and EN 50121-4:2016 table 3.2.
7 Complies with EN 50121-3-2:2016 table 3.3 and EN 50121-4:2016 table 3.3.
8 Corresponds to EN 50121-3-2:2016 table 3.1 and EN 50121-4:2016 table 3.1 (radio frequency common mode).
9 Complies with EN 50121-4:2016 table 2.3 (Power frequency magnetic field, AC input).

Emissions

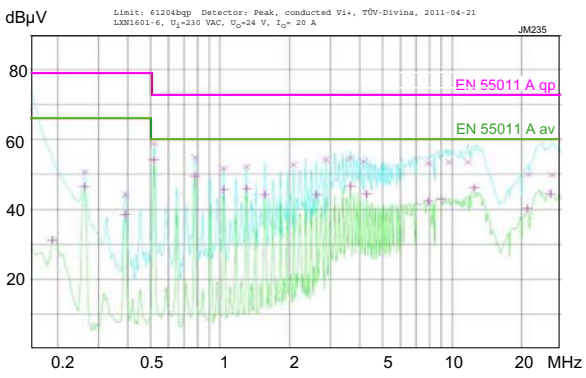

Fig. 11
Conducted emissions for LXN1601-6:
Typical disturbances, peak and quasi-peak at input L as per EN 55011, measured at V_i = 230 VAC and $I_{o\ nom}$.

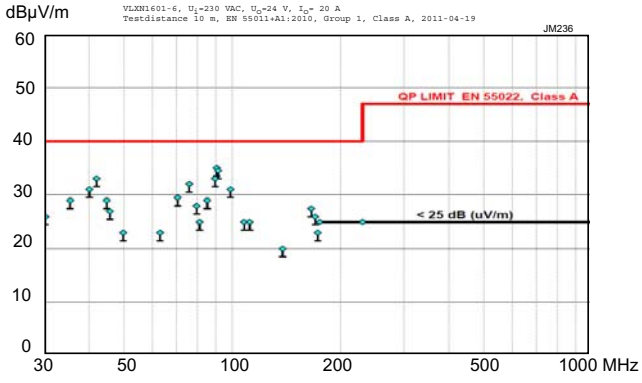

Fig. 12
Radiated emissions for LXN1601-6:
Typical electromagnetic field strength (quasi-peak) in 10 m distance as per EN 55011, $V_{i\ nom}$ and $I_{o\ nom}$.
Ferrite KEKitagawa TRCN-28-16-20 with 2 turns on input cable.

Table 9: Harmonics and flicker

Phenomenon	Standards	Conditions	Results
Harmonics	EN 61000-3-2:2006	V_i = 230 V, $V_{o\ nom}$, $I_{o\ nom}$	Class A, D
Voltage fluctuation and flicker	EN 61000-3-3 + A2:2005	V_i = 230 V, $V_{o\ nom}$, $I_{o\ nom}$	Complied

Immunity to Environmental Conditions

Table 10: Mechanical stress and climatic

Test method		Standard	Test conditions		Status
Cab	Damp heat steady state	IEC/EN 60068-2-78 MIL-STD-810D sect. 507.2	Temperature: Relative humidity: Duration:	40 $^{\pm 2}$ °C 93 $^{+2/-3}$ % 56 days	Converter not operating
Kb	Salt mist, cyclic (sodium chloride NaCl solution)	IEC/EN 60068-2-52	Concentration: Duration: Conditions: Storage duration:	5% (30 °C) 2 h per cycle 40 °C, 93% rel. humidity 3 cycles of 22 h	Converter not operating
Eb	Bump (half-sinusoidal)	IEC/EN 60068-2-29 MIL-STD-810D sect. 516.3	Acceleration amplitude: Bump duration: 6000 bumps:	25 g_n = 245 m/s^2 11 ms 1000 in each direction	Converter not operating, wall-mounted[1]
			Acceleration amplitude: Bump duration: 6000 bumps:	10 g_n = 98.1 m/s^2 11 ms 1000 in each direction	Converter not operating, on DIN-rail [2]
Fc	Vibration (sinusoidal)	IEC/EN 60068-2-6 MIL-STD-810D sect. 514.3	Acceleration amplitude and frequency (1 Octave/min): Test duration:	0.35 mm (10 – 60 Hz) 5 g_n = 49 m/s^2 (60 – 2000 Hz) 7.5 h (2.5 h each axis)	Converter operating, wall-mounted[1]
			Acceleration amplitude and frequency (1 Octave/min): Test duration:	0.25 mm (10 – 60 Hz) 2 g_n = 19 m/s^2 (60 – 2000 Hz) 7.5 h (2.5 h each axis)	Converter operating, on DIN-rail [2]
Ea	Shock (half-sinusoidal)	IEC/EN 60068-2-27 MIL-STD-810D sect. 516.3	Acceleration amplitude: Bump duration: Number of bumps:	50 g_n = 490 m/s^2 11 ms 18 (3 in each direction)	Converter not operating, wall-mounted[1]
Fh	Random vibration broad band digital control and guidance	IEC/EN 60068-2-64	Acceleration spectral density: Frequency band: Acceleration magnitude: Test duration:	0.05 g_n^2/Hz 20 – 500 Hz 4.9 $g_{n\ rms}$ 3 h (1 h each axis)	Converter operating, wall-mounted[1]
Fda	Random vibration wide band reproducibility high	IEC/EN 60068-2-35	Acceleration spectral density: Frequency band: Acceleration magnitude: Test duration:	0.01 g_n^2/Hz 20 – 500 Hz 2.2 $g_{n\ rms}$ 1.5 h (0.5 h each axis)	Converter operating, mounted on a DIN-rail [2]

[1] Wall-mounted with brackets UMB-W [HZZ00618]; see *Accessories*
[2] Fastened on a DIN-rail with 2 additional DIN-rail fixing brackets DMB-EWG; see *Accessories.* This also covers wall-mounting with brackets, because wall mounting performs better in vibration test.

Temperatures

Table 11: Temperature specifications, valid for an air pressure of 800 - 1200 hPa (800 - 1200 mbar)

Model			Standard models -6		Unit
Characteristics		Conditions	min	max	
T_A	Ambient temperature	Converter operating[1]	–40	60	°C
T_C	Case temperature		–40	90[2]	
T_S	Storage temperature	Not operating	–40	85	

[1] See *Thermal Considerations*
[2] See table 4 and 5 P_o *derating*

Failure Rates

Table 12: MTBF

Values at specified case temperature	Model	Ground benign 40 °C	Ground fixed 40 °C	Ground fixed 70 °C	Ground mobile 50 °C	Unit
MTBF [1]	LXN1801-6	400 000	110 000	50 000	40 000	h

[1] Calculated according to MIL-HDBK-217E, notice 2.

Mechanical Data

Dimensions in mm.

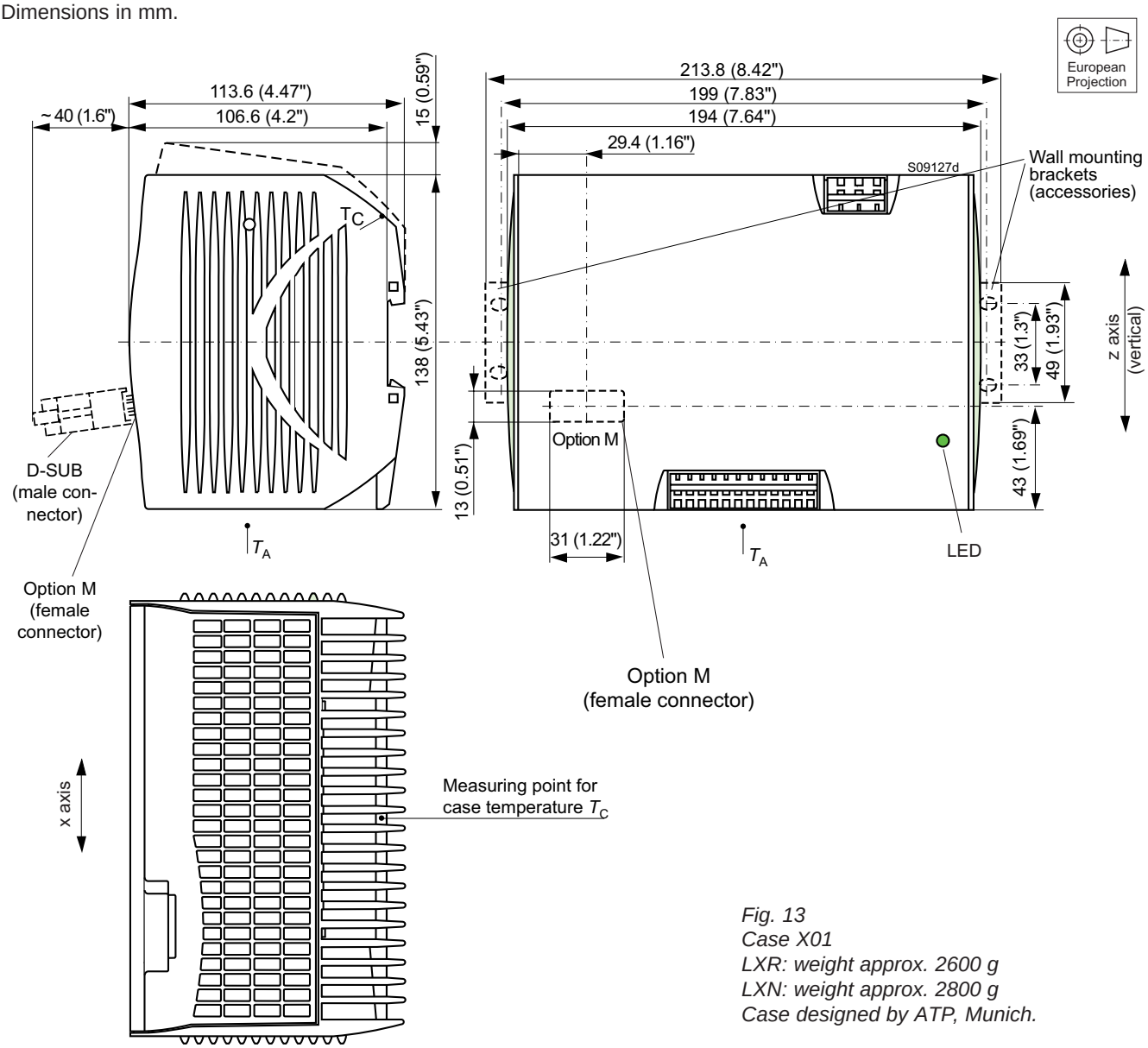

Fig. 13
Case X01
LXR: weight approx. 2600 g
LXN: weight approx. 2800 g
Case designed by ATP, Munich.

Safety and Installation Instructions

Terminal Allocation

The terminal allocation tables define the electrical potential of the converters.

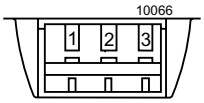

Fig. 14a
View of the input terminals (cage clamp style)

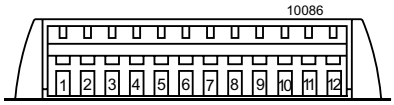

Fig. 14b
View of the output terminals (cage clamp style)

Table 13a: Input terminals of LX models

Pin no.	Pin designation	Electrical determination
1	⏚	Protective earth PE
2	N⏦	Input neutral, DC negative
3	L⏦	Input phase, DC positive

Table 13b: Terminal allocation output side

Pin	Pin des.	Single output	Double output
1	⏚	Funct. earth to load	Funct. earth to load
2	+	Output positive	Output 1 positive
3	+	Output positive	Output 1 positive
4	–	Output negative	Output 1 negative
5	–	Output negative	Output 1 negative
6	+	Output positive	Output 2 positive
7	+	Output positive	Output 2 positive
8	–	Output negative	Output 2 negative
9	–	Output negative	Output 2 negative
10	AUX1	Options 1	Options 1
11	AUX2	Options 2	Options 2
12	⏚	Funct. earth to load	Funct. earth to load

Note: If no options are fitted, terminals 11 and 12 are not connected.

Installation Instructions

The X Series converters are components, intended exclusively for inclusion within other equipment by professional installers. The installation must strictly follow the national safety regulations in compliance with the enclosure, mounting, creepage, clearance, casualty, markings and segregation requirements of the end-use application.

DIN-rail mounting is possible with the built-in snap-fit device on a DIN-rail. This fulfills the mechanical transport requirements as per ETSI 300019-1-2, class 2 (vertical).

To fulfill the requirements of IEC 721-3-2, class 2.1 (vertical), 2 additional fixing brackets HZZ00624-G (see *Accessories)* must be fitted on the bottom side of the DIN-rail. For heavy duty applications, we recommend installing all 4 fixing brackets HZZ00624-G.

Chassis or **wall mounting** is possible with the wall-mounting brackets HZZ00618 (see *Accessories)*. This complies with IEC 721-3-2, class 2.2 (vertical and horizontal).

> **Caution**: Install the converters vertically, and make sure that there is sufficient airflow available for convection cooling. The minimum space to the next device should be: top/bottom: 30 mm, left/right: 20 mm.

The converters of the X Series are class I equipment. Input terminal 1 (⏚) and the output terminals 1 and 12 (⏚) are reliably connected to the case. For safety reasons it is

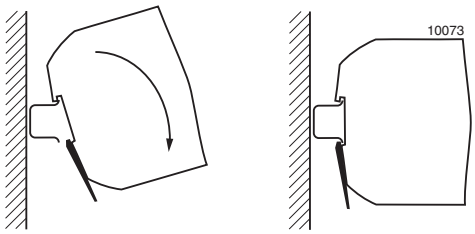

Fig. 15a
Snap-fit mounting to DIN-rail.

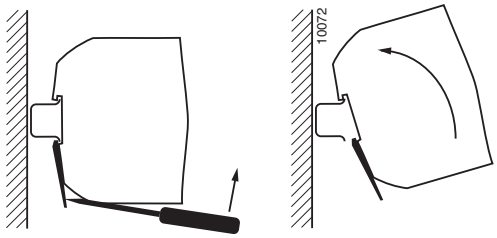

Fig. 15b
Dismounting from DIN-rail. Use proper tool (min. 3 mm screwdriver) and adequate force.

essential to connect the input terminal 1 (⏚) with protective earth. Output terminals 1 and 12 can be used to connect the output voltage(s) or the load to functional earth.

Leakage Currents

Leakage currents flow due to internal leakage capacitance (mainly the Y-capacitors). The current values are proportional to the voltage V_i and the frequency f_i of the supply (mains). The leakage currents are specified at maximum operating input voltage, provided that phase, neutral, and protective earth are correctly connected as required for class I equipment.

Caution: Leakage current may exceed 3.5 mA, if f_i > 63 Hz.

Safety of Operator-Accessible Output Circuits

If the output circuit of a converter is operator-accessible, it shall be a SELV circuit according to the safety standards IEC/EN 60950.

The converters have SELV output circuits up to an output voltage of 57.5 V. However, if the isolated outputs are connected to another voltage source or connected in series with a total of >57.5 V, the outputs are hazardous.

LED Indicator

A green LED is activated, when the output voltage V_o is within the normal operating tolerance band.

Note: This LED is also activated, when the converter is not powered by the input, but a loaded battery is connected to the output.

Description of Options

Single options D1, D2, D5, R are available on the AUX1 terminal (10), referenced to Vo– or Vo2–.

Option M1 and **M2** designate a combination of several options accessible via a D-SUB connector or in some cases on the AUX1 and AUX2 terminals. Option M1 includes the function SD.

Note: In double-output models, the options D1, D5, R, and SD concern only output 2 connected to terminals 6, 7, 8, and 9.

Single Options Using the AUX1 Pin

The connection is shown in the figure below. For the description refer to *Adjustment of V_o or V_{o2} (*next section).

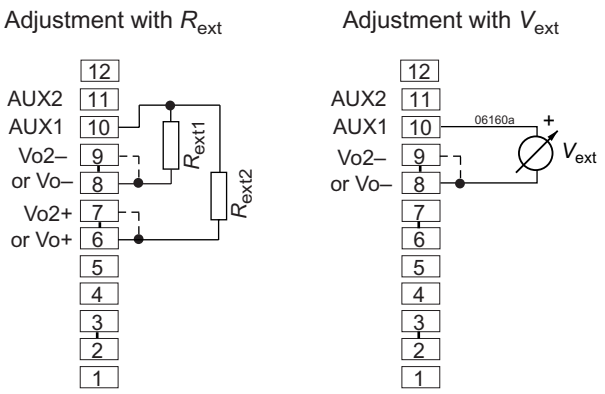

Fig. 17
Connection of adjust resistors or an external voltage source to adjust the output voltage V_o or V_{o2} (option M1 or M2 not fitted)

Table 15: Pin allocation of the 9 pin D-SUB connector

Pin	Designation	Description
1	GND1[1]	System ground / common signal return
2	R	R input[3]
3	VCC[2]	Positive supply voltage (≈ output 2)
4	D1	Output voltage monitor $V_{o\ low\ D1}$[3]
5	D5	Output 2 voltage monitor $V_{o\ low\ D5}$[3]
6	SD	Shutdown[3]
7	D-adj	Adjustment of threshold values of D1 or D5
8	D2	Input voltage monitor $V_{i\ low}$
9	Sys-OK	System okay (all outputs are okay)

[1] Do not connect GND1 (pin 1) with the neg. output (–)
[2] Do not connect VCC (pin 3) with the positive output (+)
[3] In double-output models, R, D1, D2, and SD concern output 2 only.

Table 16: Option board M1

Function	Description
R	Output voltage adjust[1]
D1	Output voltage monitor $V_{o\ low\ D1}$[1]
D2	Input voltage monitor $V_{i\ low}$
D5	Output 2 voltage monitor[1] (battery deep discharged): $V_{o\ low\ D5}$
Sys-OK	System okay
SD	Shutdown[1]
D-adj	Adjustment of trigger values D1 and D5

[1] In double-output models, only output 2 is concerned.

the mains via German Schuko-plugs; see also *Safety and Installation Instructions*.

Option F limits the DC input voltage to ≤250 V.

K2: System Connectors

For installation in systems using pre-assembled harnesses the converters are available with system connectors. They are UL-listed, approved for currents up to 15 A at –40 to 105 °C.

The mating system connectors with screw terminals and retainers are delivered together with every converter with option K2. Use max. 2.5 mm^2 (AWG 12) solid or stranded wires, or max. 1.5 mm^2 (AWG 14) stranded wires with crimp termination, stripped length 6 mm. Tightening torque of input/output terminals: max. 0.79 Nm (7 lbs.in.).

G: RoHS

RoHS-compliant for all six substances.

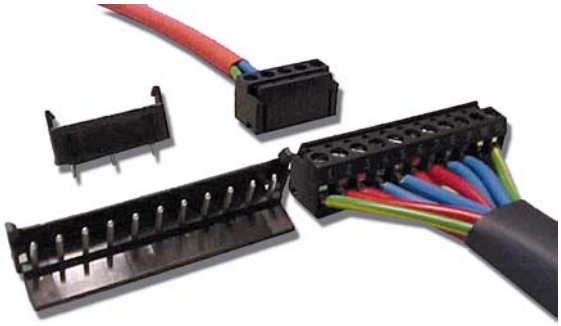

Fig. 20
System connectors Option K2

Accessories

Shock-Resistant Wall Mounting

Set of wall mounting brackets HZZ00618-G (UMB-W)

Content: 2 clamps, 4 countersunk screws M4, washers, and spring washers.

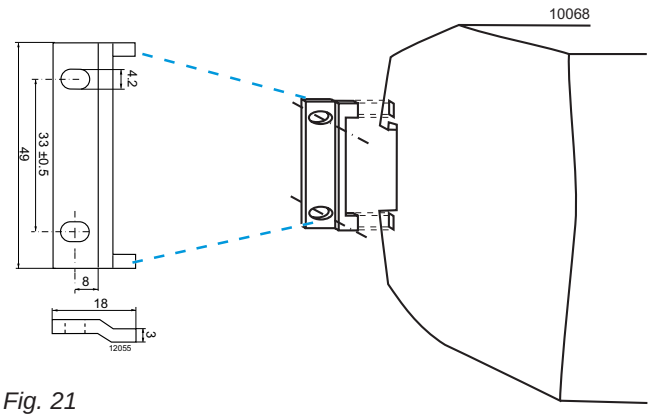

Fig. 21
Wall mounting bracket HZZ00618-G

Fig. 22
Wall mounting with mounting brackets HZZ00618-G

DIN-Rail Fixing Brackets HZZ00624-G

For DIN-Rail vibration-proof fastening, use a set of brackets HZZ00624-G (DMB-EWG). For heavy-duty application 2 sets (= 4 brackets) are preferable.

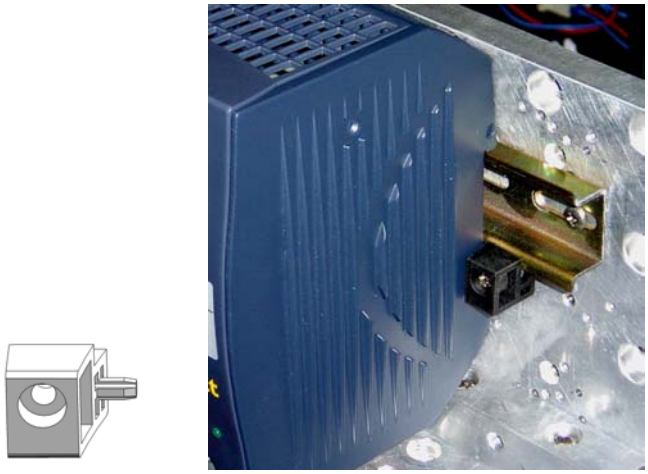

Fig. 23
One of four DIN-rail fixing brackets HZZ00624-G (DMB-EWG)

Protective Covers over Terminals

Protective covers are available to avoid touching of the terminals. HZZ01220-G contains in a bag a plastic cover with length A = 26.5 mm for the primary terminals and a second cover with length A = 64 mm for the secondary terminals; see fig. 24. Not with option K.

Content: 2 covers to protect the input and output terminals.

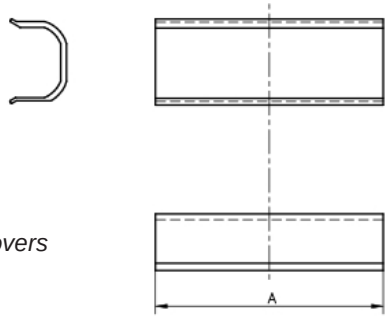

Fig. 24
Protective covers
HZZ01220-G

Battery Temperature Sensor

To charge lead-acid batteries according to their temperature different types of temperature sensors are available, (see *Battery Charging and Temperature Sensor* in this data sheet and the *Temperature Sensor data sheet* at *our website.*

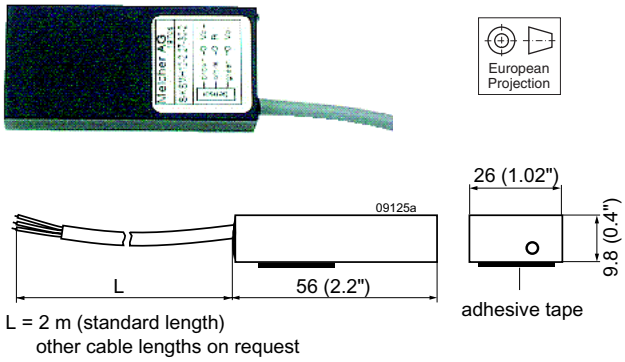

Fig. 25
Temperature sensor

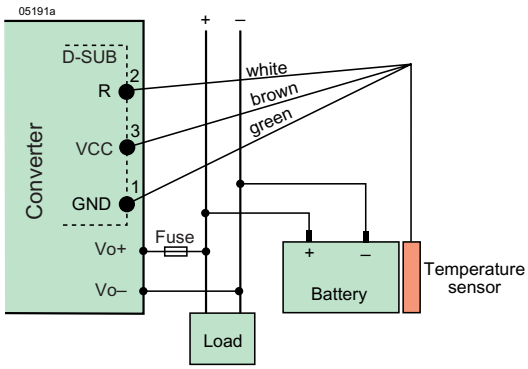

Fig. 26
Connection of a temperature sensor

Table 21: Sensors for converters with standard R input

Battery voltage nom.[V]	Sensor type	Cell voltage [V]	Cell temp. coefficient [mV/K]	Cable length [m]
24	S-KSMH24-2.27-30-2	2.27	–3.0	2
24	S-KSMH24-2.27-35-2	2.27	–3.5	2
24	S-KSMH24-2.31-35-0	2.31	–3.5	4.5
24	S-KSMH24-2.31-35-2	2.31	–3.5	2
24	S-KSMH24-2.35-35-2	2.35	–3.5	2
48	S-KSMH48-2.27-30-2	2.27	–3.0	2
48	S-KSMH48-2-27-35-2	2.27	–3.5	2

For additional accessory product information, see the accessory data sheets listed with each product series or individual model at our website.