30, 50 Watt AC-DC Coverters

Convert Simply 30, 50

Universal input range 85...264 V AC
Single output 12, 24 or 48 V DC
3 kV AC I/O electric strength test voltage

- Extremely compact design
- Battery charger versions
- Operating ambient temperature range –10...50°C with convection cooling

Safety according to IEC/EN 60950

Summary

The Convert Simply front end modules represent a family of 30 and 50 watt DIN-rail mountable AC-DC converters for use as rectifiers or battery chargers. Fully encapsulated plastic case, compact size and high reliability make the LOR 4000, LOK 4000 series an excellent choice when a DIN-Rail mountable AC-DC converter in space critical applications is required. The universal input range and a built-in input filter allows flexible operation in a wide variety of electronic equipment and enables world wide connection to the mains.

The units are available as rectifiers with 12 V or 24 V single outputs as well as battery chargers for 12 V or 24 V batteries. The output voltage can be adjusted via the R input.

Safety approvals and EMC fully comply with world wide requirements.

Key applications

Typical applications are: powering building controls, factory automation, industrials controls, instrumentation, electromagnetic drives, fans and other DC loads.

Type Survey and Key Data

Table 1: Type survey

Output 1		**Input voltage** [1]	**Rated power**	**Efficiency** [2]	**Type**	**Options**
$U_{o\,nom}$ [V DC]	$I_{o\,nom}$ [A]	U_i [V AC, 47...63 Hz] [V DC, 88...372]	T_A = 50°C $P_{o\,tot}$ [W]	η_{typ} [%]		
12	4	85...264	48	82	LOK 4301-2R	F, K
12...15	3.6	85...264	49	82	LOK 4140-2RLD	F, K
24	1.25	85...264	30	84	LOR 4601-2	F, K
24	2	85...264	48	84	LOK 4601-2R	F, K
24...30	1.8	85...264	49	84	LOK 4240-2RLD	F, K
48	1	85...264	48	84	LOK 4801-2R	F, K
48...60	0.9	85...264	49	84	LOK 4740-2RLD	F, K

[1] Derating to 85% of $P_{o\,nom}$ below U_i = 105 V AC, 110 V DC.
[2] Efficiency at $U_{i\,rated}$ and $I_{o\,nom}$.

Table of Contents

Type Key

Type Key LOK 4 1 4 0 -2 R L D F K

Series		LOK
Number of outputs		4
Output	12 V rectifier version	3
	24 V rectifier version	6
	48 V rectifier version	8
	12...15 V battery charger	14
	24...30 V battery charger	24
	48...60 V battery charger	74
	other voltages or specs.	02...99
Ambient temperature range T_A:	–10...50°C	-2
Auxiliary functions and options:	Output voltage control input	R
	Rectangular output characteristic	L [1]
	Output voltage OK signal	D
	Built-in second fuse (option)	F
	No internal fuse (option)	F1 [2]
	K system connectors (option)	K

[1] Battery charger version
[2] For operation from high DC input together with external fuses.

Examples: LOK 4140-2R: AC-DC converter, battery charger version, providing 12...15 V/3.6 A at the output
LOK 4601-2R: AC-DC converter, rectifier version, providing 24 V/2 A, 48 W at the output

Functional Description

The Convert Simply 30 and 50 front end modules are fly back converters with a fixe frequency of 100 kHz. The battery charger modules LOK 4140-2RLD and LOK 4240-2RLD have a rectangular *U*/*I* output characteristic. The rectifier modules LOK 4301-2 and LOK 4601-2 have over-load protection working in a hiccup mode.

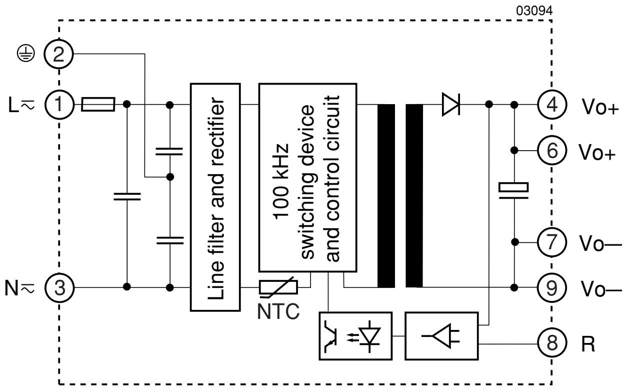


Fig. 1
Block diagram LOK 4301 and LOK 4601, rectifier version

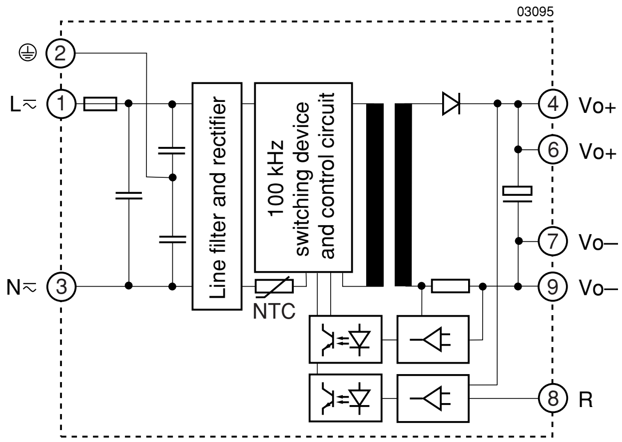


Fig. 2
Block diagram LOK 4140 ,LOK 4240 and LOK 4740, battery charger version

Electrical Input Data

General Condition: T_A = 25°C unless otherwise specified

Table 2: Input data

Characteristics		LOK	LOR	Unit
$U_{i\,rated}$	Rated input voltages	100...240	100...240	V AC
$U_{i\,nom}$	Nominal input voltage	230	230	
U_i	Input voltage range	85...264	85...264	
		88...372	88...372	V DC
f_i	Line frequency	47...63	47...63	Hz
I_i	Input current at 115/230 V AC [1]	0.8/0.4	0.52/0.26	A
$I_{inr\,max}$	Inrush current at U_i = 230 V [2]	19	18	

[1] At $I_{o\,nom}$.
[2] Inrush current limitation by a 16 Ω NTC

Electrical Output Data

General Conditions:
- T_A = 25°C unless otherwise specified.
- Trim input not connected.

Table 3a: Output data

Output			**LOK 4301-2R**			**LOR/LOK 4601-2R**			**LOK 4801-2R**			
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	Unit
U_o	Output voltage	$U_{i\,nom}$, 0.5 $I_{o\,nom}$ R-input open circuit	11.82	12	12.18	23.64	24	24.36	47.28	48	48.72	V
$U_{o\,adj}$	Adjustable voltage range		10.8		13.2	21.6		26.4	43.2		52.8	
$I_{o\,nom}$	Nominal output current	$U_{i\,min}$...$U_{i\,max}$		4000			1250/2000			1000		mA
u_o	Output voltage noise (BW = 20 MHz)	$U_{i\,nom}$ $I_{o\,nom}$		100	150		100	150				mV_{pp}
$\Delta U_{o\,U}$	Static line regulation	$U_{i\,min}$...$U_{i\,max}$, 0.5 $I_{o\,nom}$			±1			±1			±1	%
$\Delta U_{o\,I}$	Static load regulation	$U_{i\,nom}$, I_o = (1 ↔ 1) $I_{o\,nom}$			±1			±1			±1	
t_r	Transient recovery time	I_o = (1 ↔ 0.5) $I_{o\,nom}$			500			500			500	µs
t_h	Hold-up time	115/230 V AC		14/90			14/90			14/90		ms
α_{Uo}	Temperature coefficient	$U_{i\,nom}$, $I_{o\,nom}$		±0.05			±0.05			±0.05		%/K
f_s	Switching frequency			100			100			100		kHz

Table 3b: Output data

Output			**LOK 4140-2RLD**			**LOK 4240-2RLD**			**LOK 4740-2RLD**			
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	Unit
U_o	Output voltage	$U_{i\,nom}$, 0.5 $I_{o\,nom}$ R-input open circuit		12			24			48		V
$U_{o\,adj}$	Adjustable voltage range		12.0		15.0	24.0		30.0	48.0		60.0	
$I_{o\,nom}$	Nominal output current	$U_{i\,min}$...$U_{i\,max}$		3600			1800			900		mA
u_o	Output voltage noise (BW = 20 MHz)	$U_{i\,nom}$ $I_{o\,nom}$		100	150		100	150				mV_{pp}
$\Delta U_{o\,U}$	Static line regulation	$U_{i\,min}$...$U_{i\,max}$, $I_{o\,nom}$			±1			±1			±1	%
$\Delta U_{o\,I}$	Static load regulation	$U_{i\,nom}$, I_o = (1 ↔ 1) $I_{o\,nom}$			±1			±1			±1	
t_r	Transient recovery time	I_o = (1 ↔ 0.5) $I_{o\,nom}$			500			500			500	µs
t_h	Hold-up time	115/230 V AC		14/90			14/90			14/90		ms
α_{Uo}	Temperature coefficient	$U_{i\,nom}$, $I_{o\,nom}$		±0.05			±0.05			±0.05		%/K
f_s	Switching frequency			100			100			100		kHz

Thermal Considerations

If an AC-DC converter is located in free, quasi-stationary air (convection cooling) at the indicated maximum ambient temperature $T_{A\,max}$ (see table: *Temperature specifications*) and is operated at its nominal input voltage and output power, the temperature measured at the: *Measuring point of case temperature* T_C (see: *Mechanical Data*) will approach the indicated value $T_{C\,max}$ after the warm-up phase. However, the relationship between T_A and T_C depends heavily on the conditions of operation and integration into a system. The thermal conditions are influenced by input voltage, output current, airflow, temperature of surrounding components and surfaces. T_A max is therefore, contrary to $T_{C\,max}$, an indicative value only.

The relation between the maximum allowed output power $P_{o\,allowed}$ and the temperature T_A of the surrounding air is given in fig.: *Maximum allowed output power vs. ambient temperature*. The rates apply if the AC-DC converter is located in free, quasi-stationary air (convection cooling).

Note: Sufficient forced cooling allows T_A to be higher than the value given in the table if $T_{C\,max}$ according to the table is not exceeded.

Caution: The installer must ensure that under all operating conditions T_C remains within the limits stated in the table: *Temperature specifications*.

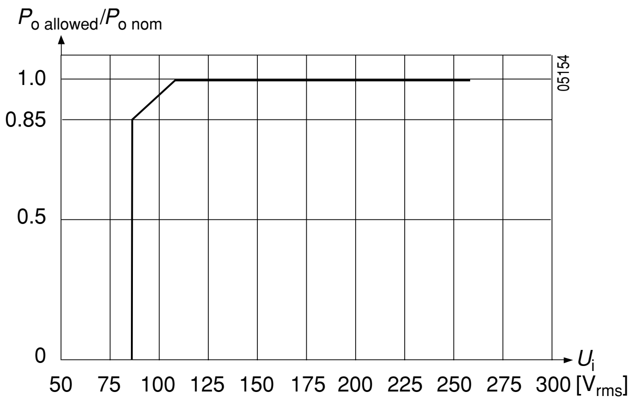


Fig. 3
Maximum allowed output power versus input voltage at T_A 50°C. LOK 4301-2R, LOK 4601-2R.

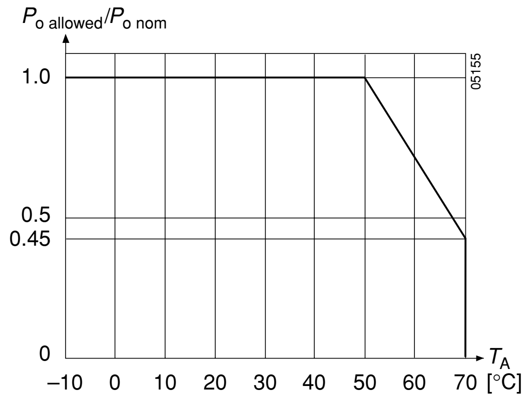


Fig. 4
Maximum allowed output power versus ambient temperature at U_i >105 V. LOK 4301-2R, LOK 4601-2R.

Auxiliary Functions

Adjustable Output Voltage (R input)

As a standard feature, the LOK units offer adjustable output voltage by using the control input R. If the R pin is left open-circuit, the output voltage is set to $U_{o\,nom}$. (see: *Output data*)

The R input is referenced to the secondary side of the converter. Adjustment of the output voltage is possible by means of either an external resistor or a voltage source.

a) Adjustment by means of an external resistor R_{ext1}:

Depending upon the value of the required output voltage, the resistor shall be connected

either: Between the R terminal and Vo– to achieve an output voltage adjustment range of approximately U_o = 90...100 % $U_{o\,nom}$.(LOK 4301, 4601 and 4801 types)

$$R_{ext1} \approx 4\ \text{k}\Omega \cdot \frac{U_o}{U_{o\,nom} - U_o}$$

or: Between the R terminal and Vo+ to achieve an output voltage range of approximately U_o = 100...110% $U_{o\,nom}$ for rectifier versions and 100...125% $U_{o\,nom}$ for battery chargers.

$$R_{ext2} \approx 4\ \text{k}\Omega \cdot \frac{(U_o - 2.5\ \text{V})}{2.5\ \text{V} \cdot (U_o/U_{o\,nom} - 1)}$$

b) Adjustment by means of an external voltage U_{ext} between Vo– and R terminal to achieve an output voltage adjustment range of approx. 90...110% $U_{o\,nom}$ (LOK 4301, 4601 and 4801 types), 100...125% $U_{o\,nom}$ for battery chargers.

$$U_{ext} \approx \frac{U_o \cdot 2.5\ \text{V}}{U_{o\,nom}}$$

Attempting to adjust the output below this range will cause the converter to shutdown (hiccup mode).

Note: Applying an external control voltage >2.75 V may damage the converter.

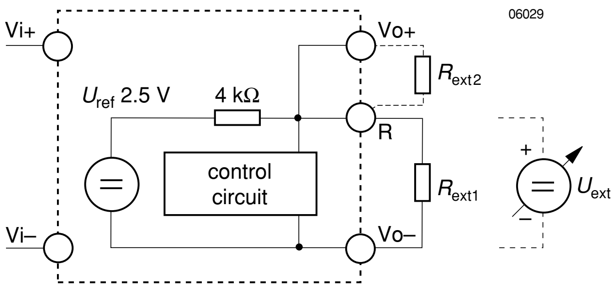


Fig. 5
Output voltage control for single output units by means of the R-input

Output Overload Protection

Battery charger versions LOK 4140-/4240- and 4740-2RLD have a rectangular current limitation which limits the output current to within (1...1.3) • $I_{o\ nom}$. The rectifier types LOK 4301-/4601- and 4801-2 are protected against over-load by a current limiting device which shuts down the converter in overload condition. It automatically restarts after removal of the overload condition (hiccup mode).

Outputs Connected in Series

Two or more units supplying the same or different output voltages may be connected in series. The value of the maximum output current to be taken is defined by that unit providing the lowest current limiting value. It should be assured that the outputs do not feed backwards into each other caused by their different rise/fall times at switch-on/off cycles by adding reverse polarity diodes across each output.

Parallel Operation

Only possible with battery charger versions.
The outputs of several units of the battery charger types with equal output voltage (e.g. several LOK 4240-2R) can be connected in parallel.

Remote control by Temperature Sensor

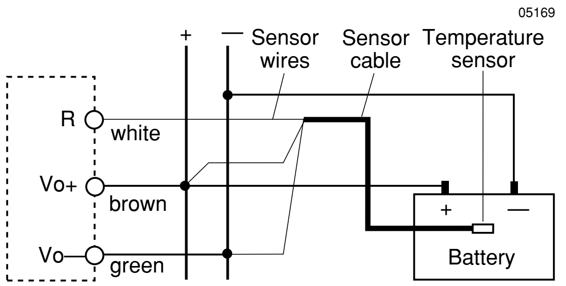


Fig. 6
Voltage setting by a temperature sensor, wiring diagram

The temperature sensor provides a temperature compensated charging process for lead acid batteries.

Battery Charging/Temperature Sensor

The LOK 4140/4240/4740 are intended for sealed lead acid battery charger applications. For optimum battery charging and extended life time of the battery an external temperature sensor may be connected to the R-input. The sensor should be mounted as close as possible to one of the poles of the battery.

Depending upon the cell voltage and the temperature coefficient of the battery, different temperature sensors are available. If no sensor is used the float charge voltage should be adjusted with a suitable resistor. (see: *Adjustable Output voltage*)

For more information please contact Power-One.

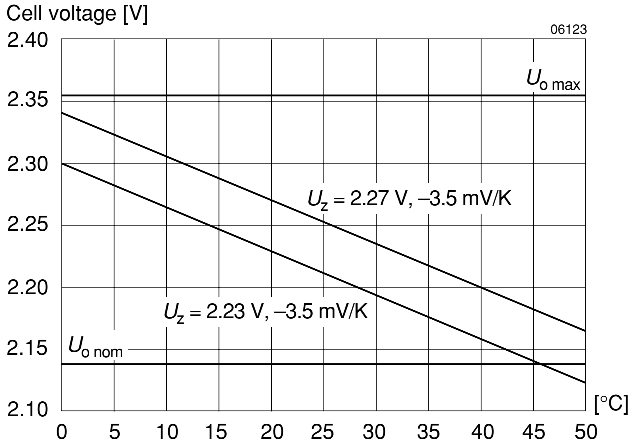


Fig. 7
Float charge voltage vs. temperature for defined temperature coefficient.

Feature D
Output Voltage OK Signal

The D-output is referenced to Vo– and monitors the output voltage U_o. If U_o drops below U_{ot}, the D-output will be disabled (open-collector circuit). The circuitry works independently of the input voltage and can therefore be used as battery-low indicator.

Table 4:

Conditions		LOK 4301-2RLD LOK 4140-2RLD min	max	LOK 4601-2RLD LOK 4240-2RLD min	max	LOK 4801-2RLD LOK 4740-2RLD min	max	Unit
U_{ot}		10	10.5	20	21	40	42	V
U_D	$U_o \leq U_{ot}$		60		60		60	
	$U_o > U_{ot}$, $I_{oD} < 50$ mA		0.6		0.6		0.6	

Electromagnetic Compatibility (EMC)

Immunity

A metal oxide VDR together with an internal input fuse and input filter form an effective protection against high input transient voltages which typically occur in most installations. The LOR 4000 and LOK 4000 family has been successfully tested to the following specifications:

Table 5: Immunity type tests

Phenomenon	Standard [1]	Level	Coupling mode [2]	Value applied	Waveform	Source imped.	Test procedure	In oper.	Per-form. [3]
Electrostatic discharge	IEC/EN 61000-4-2	2	air discharge	8000 V_p	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	B
Electromagnetic field	IEC/EN 61000-4-3	2	antenna	3 V/m	AM 80% 1 kHz	n.a.	26…1000 MHz	yes	A
Electrical fast transient/burst	IEC/EN 61000-4-4	3	direct, i/⏚, +i/–i	1 kV_p	bursts of 5/50 ns 2.5/5 kHz over 15 ms; burst period: 300 ms	50 Ω	1 min positive 1 min negative transients per coupling mode	yes	B
Surge	IEC/EN	3	i/⏚	2 kV_p	1.2/50 µs	12 Ω	5 pos. and 5 neg. surges per	yes	
	61000-4-5	2	+i/–i	1 kV_p		2 Ω			

[1] Related and previous standards are referenced in: *Technical Information: Standards* [2] i = input, o = output, c = case.
[3] A = Normal operation, no deviation from specifications, B = Normal operation, temporary deviation from specs possible.

Emission

Internal input filtering keeps the conducted noise of the units within the frequency range of 10 kHz to 30 MHz below level B according to EN 55011 and EN 55022 standards (CISPR 11/22 respectively).

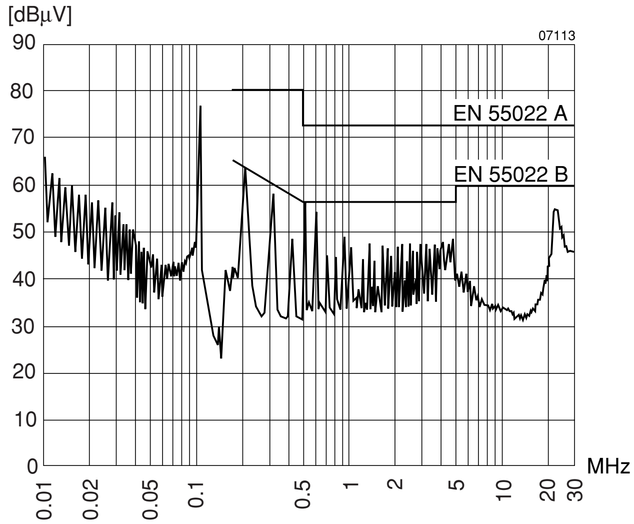


Fig. 8
Typical disturbance voltage (quasi-peak) at the input according to CISPR 11/22 and EN 55011/22, measured at $U_{i\ nom}$ and $I_{o\ nom}$. e.g. LOK 4601-2R, U_i = 230 V AC.

Immunity to Environmental Conditions

Table 6: Mechanical stress

Test Method		Standard	Test Conditions		Status
Ca	Damp heat steady state	IEC/DIN IEC 60068-2-3 MIL-STD-810D section 507.2	Temperature: Relative humidity: Duration:	$40^{\pm 2}$ °C $93^{+2/-3}$ % 21 days	Unit not operating
Ea	Shock (half-sinusoidal)	IEC/EN/DIN EN 60068-2-27 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	15 g_n = 147 m/s² 11 ms 18 (3 each direction)	Unit operating
Eb	Bump (half-sinusoidal)	IEC/EN/DIN EN 60068-2-29 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	10 g_n = 98 m/s² 11 ms 6000 (1000 each direction)	Unit operating
Fc	Vibration (sinusoidal)	IEC/EN/DIN EN 60068-2-6 MIL-STD-810D section 514.3	Acceleration amplitude: Frequency (1 Oct/min): Test duration:	0.15 mm (10...60 Hz) 2 g_n = 20 m/s² (60...150 Hz) 10...150 Hz 3.75 h (1.25 h each axis)	Unit operating

Table 7: Temperature specifications

Characterisitcs		Conditions	min	max	Unit
T_A	Ambient temperature	Operational [1]	–10	50	°C
T_C	Case temperature		–10	80	
T_S	Storage temperature	Non operational	–40	85	

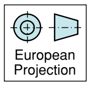
[1] See: *Thermal Consideration.*

Table 8: MTBF Values

MTBF	Type	Ground benign	Ground fixed		Ground mobile
		T_C = 40°C	T_C = 40°C	T_C = 70°C	T_C = 50°C
According to MIL-HDBK-217F, notice 2	LOK				

Mechanical Data

Dimensions in mm. Tolerance ±0.3 mm unless otherwise indicated.



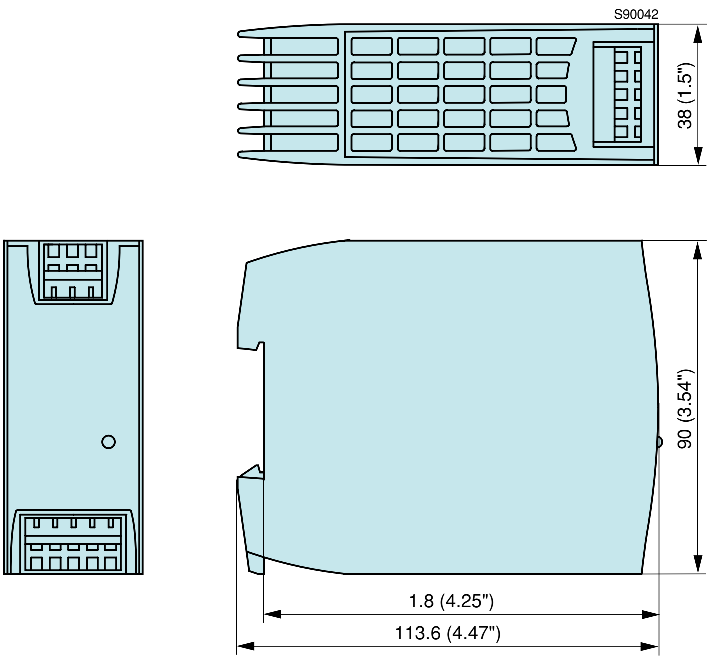


Fig. 9

Safety and Installation Instructions

Terminal Allocation

The terminal allocation table defines the electrical potentials of the AC-DC converters. For mechanical positions of the terminals see: *Mechanical Data*.

Table 9: Terminal allocation

Terminal	Electrical	LOK	LOR
1	Input	L≂	L≂
2	Protective earth	⏚	⏚
3	Input	N≂	N≂
4	Output (positive)/D	Vo+	Vo+/D
5	Output (positive)	Vo+	Vo+
6	Output (negative)	Vo–	Vo–
7	Output (negative)	Vo–	Vo–
8	n.c./R input	n.c.	R

Standards and approvals

LOR/LOK AC-DC converters correspond to class I equipment. All types are UL recognized according to UL 1950, UL recognized for Canada to CAN/CSA C22.2 No. 950-95 and LGA approved to IEC/EN 60950 standards.

The units have been evaluated for:
- Building in
- Double or reinforced insulation between input and output, based on 250 V AC
- Basic insulation between input and earth
- Operational insulation between output and earth
- The use in a pollution degree 2 environment
- Connecting the input to a primary circuit with overvoltage category II.

The AC-DC converters are subject to manufacturing surveillance in accordance with the above mentioned UL, CSA, EN and with ISO 9001 standards.

Protection Degree

IP 20: All units.

Installation Instructions

The LOK AC-DC converters are components, intended exclusively for inclusion within other equipment by an industrial assembly operation or by professional installers. 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. See also: *Technical Information: Installation and Application*.

Connection to the system shall be according to: *Terminal allocation* and: *Mechanical Data*. Check for hazardous voltages before altering any connections.

Ensure that a unit failure (e.g. by an internal short-circuit) does not result in a hazardous condition. See also: *Safety of operator accessible output circuit*.

The phase input (L≂) is internally fused by a 1.6 A slowblow type. It is not customer-accessible. This fuse is designed to protect the unit in case of overcurrent. Option F or external fuses in the wiring to one or both input pins (L≂ and/or N≂) may therefore be necessary to ensure compliance with local requirements.

A second fuse in the wiring to the terminal N≂ is needed if:

- Local requirements demand an individual fuse in each source line
- Neutral and earth impedance is high or undefined
- Phase and neutral of the mains are not defined or cannot be assigned to the corresponding termials (L≂ to phase and N≂ to neutral).

Important: Do not open the modules, or guarantee will be invalidated.

Make sure that there is sufficient air flow available for convection cooling. This should be verified by measuring the case temperature when the unit is installed and operated in the end-use application. The maximum specified case temperature $T_{C\ max}$ shall not be exceeded. See also: *Thermal Considerations*.

Isolation

The electric strength test is performed as a factory test in accordance with IEC/EN 60950 and UL 1950 and should not be repeated in the field. Power-One will not honour any guarantee/warranty claims resulting from electric strength field tests.

Important: Testing by applying AC voltages will result in high and dangerous leakage currents flowing through the Y-capacitors (see fig.: *Block diagram)*

Table 10: Isolation

Characteristic		Input to protective earth	Input to output	Output to protective earth	Unit
Electric strength test voltage	Required according to IEC/EN 60950	1.5	3.0 [1]	0.5	kV_{rms}
		2.1	4.2 [1]	0.7	kV DC
	Actual factory test 1 s	2.8	5.6 [1]	1.4	
	AC test voltage equivalent to actual factory test	2.0	4.0 [1]	1	kV_{rms}
Insulation resistance at 500 V DC		>300	>300	>300	MΩ

[1] In accordance with IEC/EN 60950 only subassemblies are tested in factory with this voltage. [2] Tested at 300 V DC.

For creepage distances and clearances refer to: *Technical Information: Safety.*

Leakage Currents in AC-DC operation

Leakage currents flow due to internal leakage capacitance and RFI suppression Y-capacitors. The current values are proportional to the mains voltage and nearly proportional to the mains frequency and are specified at an input voltage of 264 V (63 Hz) where phase, neutral and protective earth are correctly connected as required for class I equipment.

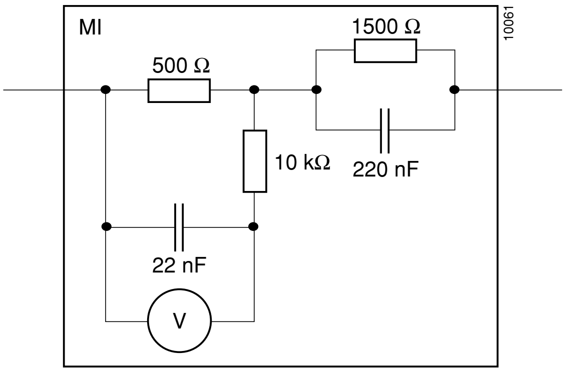


Fig. 10
Measuring instrument (MI) for earth leakage current tests according to IEC/EN 60950.

Under test conditions the leakage current flows through a measuring instrument (MI) as described in fig. *Measuring instrument for earth leakage current tests*, which takes into account impedance and sensitivity of a person touching accessible parts. The current value is calculated by dividing the measured voltage by 500 Ω. If inputs and/or outputs of O-units are connected in parallel, their individual leakage currents are added.

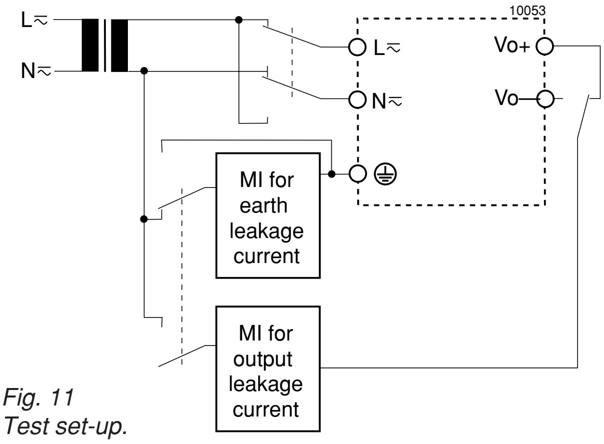


Fig. 11
Test set-up.

Table 11: Leakage currents

Characteristic		LOK	Unit
Maximum earth leakage current	Permissible according to IEC/EN 60950	3.5	mA
	Specified value at 264 V, 50 Hz	0.5	
Maximum output leakage current	Permissible according to IEC/EN 60950	0.25	
	Specified value at 264 V, 50 Hz	0.005	

Safety of operator accessible output circuit

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

The following table shows a possible installation configuration, compliance with which causes the output circuit of an O-family AC-DC converter to be an SELV circuit according to IEC/EN 60950 up to a configured output voltage (sum of nominal voltages if in series or +/– configuration) of 36 V.

However, it is the sole responsibility of the installer to assure the compliance with the relevant and applicable safety regulations. More information is given in *Technical Information: Safety*.

Table 12 : Safety concept leading to an SELV output circuit

Conditions	AC-DC converter	Installation	Result
Nominal Supply voltage	Grade of insulation between input and output, provided by the AC-DC converter	Measures to achieve the resulting safety statuts of the output circuit	Safety statuts of the AC-DC converter output circuit
Mains ≤250 V AC	Double or reinforced	Earth connection [1] and installation according to the applicable standards	SELV circuit

[1] The earth connection of terminal no. 1 has to be provided by the installer according to the relevant safety standards, e.g. IEC/EN 60950

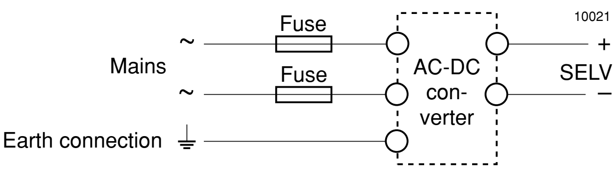


Fig. 12
Schematic safety concept.
Use fuses and earth connection as per *Installation Instructions* and table *Safety concept leading to an SELV output circuit.*

Description of Options

Table 13: Survey of options

Option	Function of option	Characteristic
F	Built-in second fuse	
F1	No internal fuse	
K	System connectors	

Option F
Built-in second fuse

A built-in second fuse in the neutral input line enables safe connection to the mains where phase and neutral are not defined or cannot be identified as e.g. in the case of plug and socket connection to the mains via Schuko-plugs, see also *Installation Instruction.*

Option F1
No internal fuse

Jumper fitted internally instead of built-in fuse. This option may be required if the units are operated from DC-input above 250 V. In such a case a suitable fuse has to be provided externally capable to blow at high DC-voltages.

Option K
System connectors

For installation into systems using preassembled harnesses the units are available with connectors fitted with screw terminals. The system connectors are UL-listed and approved for currents up to 10 A. Wire cross sections: Solid wires 1.5 mm^2, stranded wires 1 mm^2.