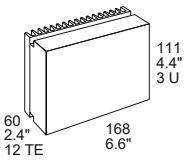
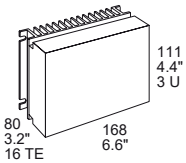
LR Series

240 – 300 Watt AC-DC & DC-DC Converters





The LR Series of AC-DC converters represents versatile power supplies ideally suitable for use in advanced electronic systems. Features include full power factor correction, good hold-up time, high efficiency and reliability, low output noise, and excellent dynamic response to load/line changes.

The converter inputs are protected against surges and transients. An input over- and undervoltage lockout circuitry disables the outputs if the input voltage is outside of the specified range. Input inrush current limitation is included to prevent circuit breakers and fuses from tripping at switch-on.

The outputs are open- and short-circuit proof.

Full input-to-output, input-to-case, output-to-case, and output to output isolation is provided. Particularly the outputs exhibit an extended insulation to the case.

FEATURES

- Class I equipment
- Universal AC input voltage range with PFC and DC input
- Inrush current limitation
- 2 isolated, adjustable outputs
- No load, overload, and short-circuit proof
- Rectangular current limiting characteristic with flexible load distribution
- Inhibit function
- Parallel operation with active current sharing
- Interruption time 20 ms
- Immunity according to EN 61000-4-2, -3, -4, -5, -6, -8
- RoHS-compliant
- Fire & smoke according to EN 45545
- All PCB boards protected by lacquer
- Very high reliability
- 5 year warranty
- AREMA compliant
- Safety-approved to the latest edition of IEC/EN 62368-1 and UL/CSA 62368-1

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POWER | PROTECT | CONNECT

Please read our datasheet & drawing disclaimer here.

LR Series

240 – 300 Watt AC-DC & DC-DC Converters

DESCRIPTION

All PCB boards are coated with a protective lacquer.

The case design allows for operation at nominal load up to 71 °C with natural cooling. If forced cooling is provided, the ambient temperature may exceed 71 °C, but the case temperature must remain below 95 °C.

A temperature sensor generates an inhibit signal, which disables the outputs when the case temperature T_C exceeds the limit. The outputs are automatically re-enabled when the temperature drops below the limit.

LED indicators display the status of the converter and allow for visual monitoring of the system at any time.

The converters can either be plugged into a 19" rack system according to IEC 60297-3, or be chassis mounted. Two heat sinks of different size and cooling plates for chassis mounting (option B, B1) are available.

MODEL SELECTION

Table 1: Model selection

Output 1		Output 2		Power	Operating Input Voltage	Efficiency				Model	Options
$V_{o\,nom}$ [V]	$I_{o\,nom}$ [A]	$V_{o\,nom}$ [V]	$I_{o\,nom}$ [A]	$P_{o\,nom}$ [W]	$V_{i\,cont}$	η_{110} [1]		η_{230} [2]			
						min [%]	typ [%]	min [%]	typ [%]		
12	10	12	10	240	90 – 264 VAC 125 – 300 VDC	90	91	90	92	LR2320-9	F0, F2, B, B1
12	12.5	12	12.5	300		90	91	90	92	LRP2320-9	
15	8	15	8	240		90	91	90	92	LR2540-9	
15	10	15	10	300		90	91	90	92	LRP2540-9	
24	5.2	24	5.2	250		90	91	90	92	LR2660-9	
24	6.25	24	6.25	300		90	91	90	92	LRP2660-9	

[1] Efficiency at T_A = 25 °C, V_i = 110 VAC, $I_{o\,nom}$, $V_{o\,nom}$
[2] Efficiency at T_A = 25 °C, V_i = 230 VAC, $I_{o\,nom}$, $V_{o\,nom}$

Part Number Description

LR 2 3 20 -9 B1

Operating input voltage $V_{i\,cont}$ (continuously):
- 90 – 264 VAC, 125 – 300 VDC ..... LR, LRP

Number of outputs 2

Nominal voltage of main output $V_{o1\,nom}$
- 12 V 3
- 15 V 5
- 24 V 6
- Other voltages [1] ..... 1 - 9

Nominal voltage of tracking output V_{o2} [2]
- 12 V 20
- 15 V 40
- 24 V 60

Other specifications or additional features [1] ..... 11 – 99

Operational temperature range: T_A:
- T_A = –40 to 71 °C, $T_C \leq$ 95 °C ..... -9
- Other [1] ..... -0, -5, -6

Auxiliary functions and options:
- Fuse options F0, F2
- Cooling plate standard case ..... B, B1

[1] Customer-specific models. No safety-relevant changes compared to the respective basic model, e.g. different mechanical details, special markings, mounted front plates, reduced output voltage, etc.
[2] The nominal voltages of both outputs are always equal.

Note: The sequence of options must follow the order above.

Example: LR2320-9B1: AC-DC converter, operating input voltage range 90 to 264 VAC, 2 isolated outputs, each providing 12 V, 10 A, cooling plate B1, RoHS-compliant for all six substances.

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Product Marking

Basic type designation: applicable approval marks, CE mark, warnings, pin designation, patents and company logo, identification of LEDs.

Specific type designation: input voltage range, nominal output voltages and currents, degree of protection, batch no., serial no., and data code including production site, modification status, and date of production.

FUNCTIONAL DESCRIPTION

The input voltage is fed via an efficient filter and a bridge rectifier to the PFC-corrected step-up converter, which generates the intermediate voltage across the bulk capacitor C_b. The inrush current is limited by the resistor R_{inr}, which is shorted by V_{inr}, after the bulk capacitor was charged.

The bulk capacitor sources a half bridge DC-DC converter and provides the power during the specified hold-up time.

The main transformer exhibits two secondary windings for the two outputs. The resultant voltages are rectified by synchronous rectifiers in order to provide the best efficiency. Their ripple voltages are smoothed by a dual choke and output filters. The control logic senses the main output voltage V_{o1} and generates the gate signals for the DC-DC converter, which are transferred by isolated drivers to the primary side.

The second output is tracking the main output voltage, but has its own current limiting circuit. If the main output voltage drops due to over current, the second output voltage will drop as well and vice versa. Primary current sensing limits the sum of both output currents, such allowing for loading the main output up to 140% of $I_{o1\ nom}$.

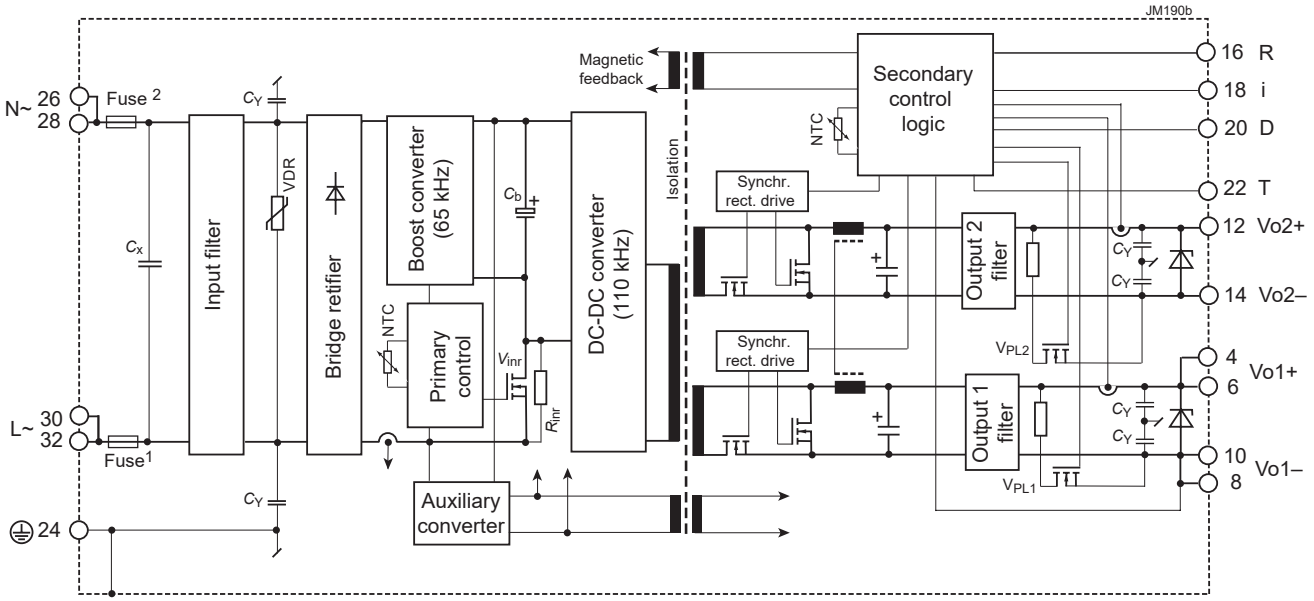
The output voltages can be adjusted by external means. Parallel operation of several converters is possible by connecting the T-pins together, in order to provide active current sharing. Both outputs can be connected in parallel or in series. They exhibit a rectangular current limitation characteristic. Switchable preloads ensure good regulation even with no load at one output.

A control output (D) and two LEDs signal correct operation of the converter. In case of an output overvoltage of the main output, the converter is disabled by a latch.

When the input voltage is too high, the overvoltage lockout disables the DC-DC converter and protects it from damage.

Temperature sensors on the primary and secondary side prevent the converter from excessive warm-up.

A cooling plate for chassis-mounting is available (opt. B, B1).



1 Fuse not fitted with opt. F0
2 Additional fuse only fitted with opt. F2

Fig. 1
Block diagram

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ELECTRICAL INPUT DATA

General conditions:

- T_A = 25 °C, unless T_C is specified.
- Pin 18 (i) connected to pin 8, pin 16 (R), pin 18 (D), and pin 22 (T) left open-circuit.

Table 2: Input data

Model			LR			LRP			Unit
Characteristics		Conditions	min	typ	max	min	typ	max	
V_i	Rated input voltage range	I_o = 0 – $I_{o\,nom}$ $T_{C\,min}$ to $T_{C\,max}$	100		240	100		240	VAC [1]
$V_{i\,cont}$	Operating input voltage range		90		264	90		264	
$V_{i\,DC}$	Continuous DC input voltage range		125		300	125		300	VDC
$V_{i\,nom}$	Nominal input voltage [1]	50 – 60 Hz		(110) 230			(110) 230		VAC
I_i	Input current	$V_{i\,nom}$, $I_{o\,nom}$		(2.5) 1.2			(3.1) 1.5		A
$I_{inr\ p}$	Peak inrush current	V_i = 90 AC, $I_{o\,nom}$, t_{inr} = 60 ms			12			12	A
$P_{i\,0}$	No-load input power	$V_{i\,min}$ – $V_{i\,max}$, I_o = 0			18			18	W
$P_{i\,inh}$	Idle input power	Converter inhibited		1.3	2		1.3	2	
C_b	Boost capacitance			360			360		µF
t_{hu}	Interruption time	V_i = 0 AC or DC, $I_{o\,nom}$	20			20			ms
t_{on}	Start-up time	V_i = 0 → $V_{i\,nom}$, $I_{o\,nom}$		500			500		
$V_{i\,abs}$	Input voltage limits without damage	< 2 s	-400		400	-400		400	V_{peak}

[1] Rated input frequency: 50 – 60 Hz, operating frequency: 47 – 63 Hz.

Input Fuse and Protection

A VDR together with the input fuse and a symmetrical input filter form an effective protection against high input transient voltages.

If option F0 was chosen, the installer has to provide an external circuit breaker or fuse according to table 3. Without option F, a fuse is incorporated in the phase line (pins 30 + 32). A second fuse in the neutral line may be necessary in certain applications (option F2); see *Options* and *Installation Instructions.*

Table 3: Fuse specification

Model	Fuse rating (AC input)	Reference
LR2320, LR2540, LR2660	6.3 A, 250 V, slow, 5 × 20 mm	SOC SHV11-6.3A or LITTELFUSE 047706.3MXEP
LRP2320, LRP2540, LRP2660	6.3 A, 250 V, slow, 5 × 20 mm	

Input Under-/Overvoltage Lockout

If the input voltage is below approx. 80 VAC or exceeds $V_{i\,op\,max}$, an internally generated inhibit signal disables the outputs. If V_i is below $V_{i\,min}$, but above the undervoltage lockout level, the output voltage may be below the value specified in the tables *Electrical Output Data.*

Inrush Current Limitation

All models exhibit an electronic inrush current limitation to protect connectors and switching devices against damage.

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Efficiency

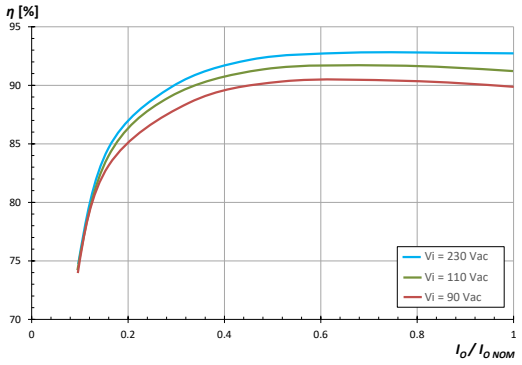

Fig. 2
Efficiency versus V_i and I_o (LRP2320 / LRP2540 / LRP2660, both outputs connected in series)

ELECTRICAL OUTPUT DATA

General Conditions:

– T_A = 25 °C, unless T_C is specified.

– Pin 18 (i) connected to pin 8, pin 16 (R), pin 20 (D), and pin 22 (T) left open-circuit.

Table 4a: Output data of LR2320 and LRP2320

Model (Nom. output voltage)				LR2320 (2 x 12 V)						LRP2320 (2 x 12 V)						Unit
Characteristics			Conditions	Output 1			Output 2			Output 1			Output 2			
				min	typ	max	min	typ	max	min	typ	max	min	typ	max	
V_o	Output voltage		$V_{i\,nom}$, 0.5 $I_{o\,nom}$	11.93	12.0	12.07		12.0		11.93	12.0	12.07		12.0		V
$V_{o\,BR}$	Output protection (suppressor diode)		Output 1, 2	14.3		15.8	14.3		15.8	14.3		15.8	14.3		15.8	V
$I_{o\,nom}$	Output current nom. [1]		$V_{i\,min}$ – $V_{i\,max}$ $T_{C\,min}$ – $T_{C\,max}$		10 [7]			10			12.5 [7]			12.5		A
I_{o1L}, I_{o2L}	Output current limit [1]			10.5		17 [7]	10.5			13		21.25 [7]	13			A
I_{o12L}	Output current limit [1, 2]			21 [2]			-			26 [2]			-			A
V_o	Output noise incl. spikes [6]		$V_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz			60			60			60			60	mV_{pp}
$V_{o\,adj}$	Adjustment by R-input [4]		$V_{i\,min}$ – $V_{i\,max}$ (0.1 – 1) $I_{o\,nom}$	6.0		13.2 [1]		[3]		6.0		13.2 [1]		[3]		V
$\Delta V_{o\,u}$	Static line/load regulation (total deviation of V_o)					±120		[3]				±120		[3]		mV
$V_{o\,d}$	Dynamic load regulation	Voltage deviation [5]	$V_{i\,nom}$, 0.5 $I_{o2\,nom}$ $I_{o1\,nom}$ ↔ 0.5 $I_{o1\,nom}$ and after turn on		±200			±200			±250			±250		mV
$t_{o\,d}$		Recovery time [5]			1			[3]			1			[3]		ms
$\alpha_{v\,o}$	Temperature coefficient of output voltage		$I_{o\,nom}$ $T_{C\,min}$ – $T_{C\,max}$			0.02		-				0.02		-		%/K

1 If V_o is increased above $V_{o\,nom}$ through R-, or T-input, the output currents should be reduced so that $P_{o\,nom}$ is not exceeded.
2 Both outputs connected in parallel
3 See *Output voltage regulation*
4 For battery charger application, a defined negative temp. coefficient can be provided by using a temp. sensor (see *Accessories)*
5 See *Dynamic load regulation*
6 Measured with a ceramic cap of 1 µF across each output.
7 I_{o1} can be increased to 140% of $I_{o1\,nom}$ if I_{o2} is reduced accordingly

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Table 4b: Output data of LR2540 and LRP2540. General conditions as per table 4a

Model (Nom. output voltage)				LR2540 (2 x 15 V)						LRP2540 (2 x 15V)						Unit
Characteristics			Conditions	Output 1			Output 2			Output 1			Output 2			
				min	typ	max	min	typ	max	min	typ	max	min	typ	max	
V_o	Output voltage		$V_{i\,nom}$, 0.5 $I_{o\,nom}$	14.91	15.0	15.09		15.0		14.91	15.0	15.09		15.0		V
$V_{o\,BR}$	Output protection (suppressor diode)		Output 1, 2	17.1		18.9	17.1		18.9	17.1		18.9	17.1		18.9	V
$I_{o\,nom}$	Output current nom. [1]		$V_{i\,min} - V_{i\,max}$ $T_{C\,min} - T_{C\,max}$		8 [7]			8			9.6 [7]			9.6		A
I_{o1L}, I_{o2L}	Output current limit [1]			8.4		13.6 [7]	8.4			10.1		16.32 [7]	10.1			A
I_{o12L}	Output current limit [1, 2]			16.8 [2]			-			19.7 [2]			-			A
V_o	Output noise incl. spikes [6]		$V_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz			75			75			75			75	mV_{pp}
$V_{o\,adj}$	Adjustment by R-input [4]		$V_{i\,min} - V_{i\,max}$ (0.1 – 1) $I_{o\,nom}$	7.5		17.25 [1]		[3]		7.5		17.25 [1]		[3]		V
$\Delta V_{o\,u}$	Static line/load regulation (total deviation of V_o)					±150		[3]				±150		[3]		mV
$V_{o\,d}$	Dynamic load regulation	Voltage deviation [5]	$V_{i\,nom}$, 0.5 $I_{o2\,nom}$ $I_{o1\,nom} \leftrightarrow 0.5\,I_{o1\,nom}$ and after turn on		±250			±250			±300			±300		mV
$t_{o\,d}$		Recovery time [5]			1			[3]			1			[3]		ms
$\alpha_{v\,o}$	Temperature coefficient of output voltage		$I_{o\,nom}$ $T_{C\,min} - T_{C\,max}$			0.02		-				0.02		-		%/K

[1] If the output voltages are increased above $V_{o\,nom}$ through R-input control, or option T, the output currents should be reduced accordingly so that $P_{o\,nom}$ is not exceeded.
[2] Both outputs connected in parallel
[3] See Output voltage regulation
[4] For battery charger applications, a defined negative temperature coefficient can be provided by using a temperature sensor (see Accessories)
[5] See Dynamic load regulation
[6] Measured with a ceramic cap of 1 µF across each output.
[7] I_{o1} can be increased to 140% of $I_{o1\,nom}$ if I_{o2} is reduced accordingly

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Table 4c: Output data of LR2660 and LRP2660. General conditions as per table 4a

Model (Nom. output voltage)				LR2660 (2 x 24 V)						LRP2660 (2 x 24 V)						Unit
Characteristics			Conditions	Output 1			Output 2			Output 1			Output 2			
				min	typ	max	min	typ	max	min	typ	max	min	typ	max	
V_o	Output voltage		$V_{i\,nom}$, 0.5 $I_{o\,nom}$	23.86	24	24.14		24		23.86	24	24.14		24		V
$V_{o\,BR}$	Output protection (suppressor diode)		Output 1, 2	28.5		31.5	28.5		31.5	28.5		31.5	28.5		31.5	V
$I_{o\,nom}$	Output current nom. [1]		$V_{i\,min} - V_{i\,max}$ $T_{C\,min} - T_{C\,max}$		5.2 [7]			5.2			6.25 [7]			6.25		A
I_{o1L}, I_{o2L}	Output current limit [1]			5.5		7 [7]	5.5			6.5		9 [7]	6.5			A
I_{o12L}	Output current limit [1, 2]			11 [2]			-			13 [2]			-			A
V_o	Output noise incl. spikes [6]		$V_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz			120			120			120			120	mV_{pp}
$V_{o\,adj}$	Adjustment by R-input [4]		$V_{i\,min} - V_{i\,max}$ (0.1 – 1) $I_{o\,nom}$	12		28 [1]		[3]		12		28 [1]		[3]		V
$\Delta V_{o\,u}$	Static line/load regulation (total deviation of V_o)					±240		[3]				±240		[3]		mV
$V_{o\,d}$	Dynamic load regulation	Voltage deviation [5]	$V_{i\,nom}$, 0.5 $I_{o2\,nom}$ $I_{o1\,nom} \leftrightarrow 0.5\,I_{o1\,nom}$ and after turn on		±400			±400			±500			±500		mV
$t_{o\,d}$		Recovery time [5]			1			[3]			1			[3]		ms
$\alpha_{v\,o}$	Temperature coefficient of output voltage		$I_{o\,nom}$ $T_{C\,min} - T_{C\,max}$			0.02		-				0.02		-		%/K

[1] If the output voltages are increased above $V_{o\,nom}$ through R-input control, or option T, the output currents should be reduced accordingly so that $P_{o\,nom}$ is not exceeded.
[2] Both outputs connected in parallel
[3] See Output voltage regulation
[4] For battery charger applications, a defined negative temperature coefficient can be provided by using a temperature sensor (see Accessories)
[5] See Dynamic load regulation
[6] Measured with a ceramic cap of 1 µF across each output.
[7] I_{o1} can be increased to 140% of $I_{o1\,nom}$ if I_{o2} is reduced accordingly

Thermal Considerations

If a 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 within the specified input voltage range with nominal load, 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 upon the conditions of operation and integration into a system. The thermal conditions are influenced by input voltage, output current, airflow, and temperature of surrounding components and surfaces. $T_{A\,max}$ is therefore, contrary to $T_{C\,max}$, an indicative value only.

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

Notes: Sufficient forced cooling or enhanced cooling with the help of cooling plates (options B, B1) allows for T_A higher than 71 °C (e.g. 85 °C), as long as $T_{C\,max}$ is not exceeded.

Thermal Protection

Two temperature sensors generate an internal inhibit signal, which disables the converter in the case of overtemperature. The outputs automatically recover when the temperature drops below the limit.

Interruption Time

The integrated storage capacitor (C_b) is loaded to the boost voltage and ensures full output voltage with nominal load during the specified interruption time of 20 ms.

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Output Protection

The outputs are protected by a suppressor diode against overvoltage, which could occur due to a failure of the internal control circuit. This suppressor diode was not designed to withstand externally applied overvoltages. Overload at any of the outputs will cause both outputs to shut-down.

Note: $V_{o\,BR}$ of the suppressor diode is specified in *Electrical Output Data*. If this voltage is exceeded, the suppressor diode generates losses and may become a short circuit.

Note: The output voltage of the first output is monitored. If it exceeds typ. 140% of $V_{o\,nom}$ for 10 ms, the converter is inhibited by a latch. To reactivate, V_i must be removed or the converter disabled through an inhibit signal to pin 18.

Each output has its own current limiting circuit, providing a rectangular output characteristic and protecting against short circuit. There is no limitation for the capacitive load, and battery charging is possible as well.

Series and Parallel Connection

Both outputs of the same converter can be series-connected or parallel-connected in order to double the output current or the output voltage respectively.

Outputs of different converters of the same model type may be series-connected.

In parallel connection of several converters, the T-pins should be interconnected so that all converters share the output current equally.

If both outputs of each converter are connected in series, Vo1– of both converters should be connected together. Interconnect the T-pins as well; see fig. 3.

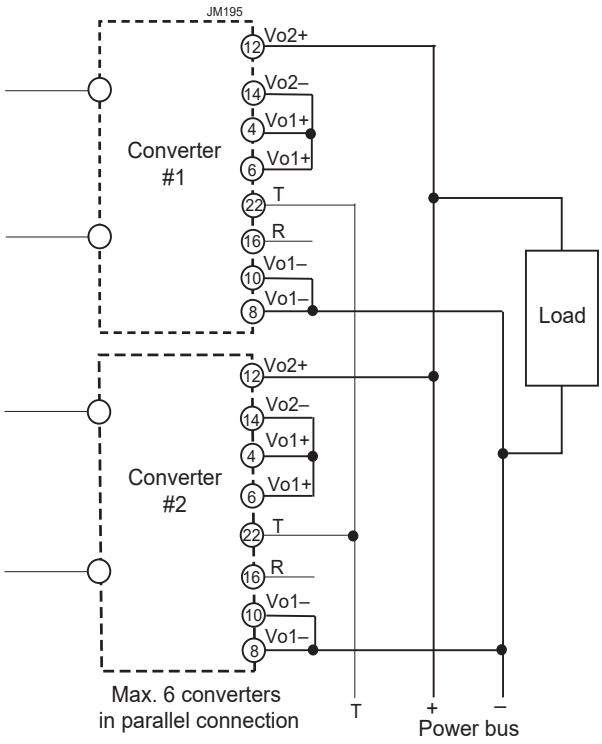

Fig. 3
Parallel connection of double-output models with both outputs connected in series. T-pins and R-pins are referenced to Vo1–.

Notes:

– Not more than 6 converters should be connected in parallel.

– If several outputs are connected in series, the resulting voltage may exceed the ES1 level.

– The R-pins should be left open-circuit. If not, the output voltages must individually be adjusted prior to paralleling within 1 to 2%, or the R-pins should be interconnected.

– Series connection of second outputs without involving their main outputs should be avoided, as regulation may be poor.

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Output Voltage Regulation

If both outputs are connected in parallel or in series, the converter exhibits a rectangular output characteristic; see fig. 4.

The typ. dynamic load regulation illustrates fig. 5.

Output 1 is under normal conditions regulated to $V_{o\,nom}$, irrespective of the output currents.

However, V_{o2} depends upon the load distribution; see fig. 6. The converters have incorporated switchable preloads and do not need a minimum load.

Note: If output 2 is not used, connect it in parallel with output 1! This ensures good regulation and efficiency.

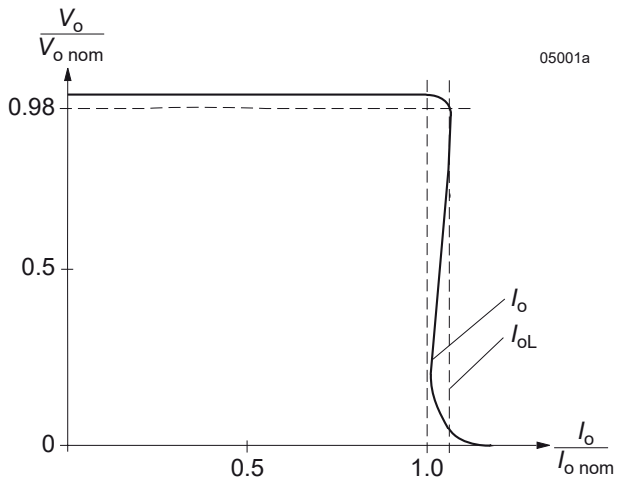

Fig. 4
Output characteristic V_o versus I_o
(both outputs connected in parallel or in series)

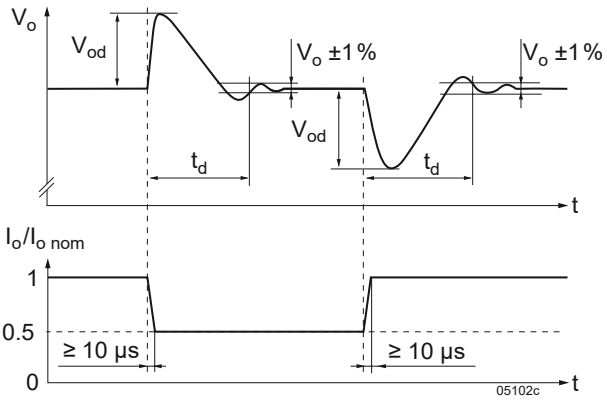

Fig. 5
Typical dynamic load regulation of V_o.

In a symmetrical configuration the output 1 is regulated to $V_{o1\,nom}$, regardless of the output currents.

However, V_{o2} depends upon the load distribution, see Fig 6a and Fig. 6b.The converters have incorporated switchable preloads and do not need a minimum load.

Note: If output 2 is not used, we recommend to connect it in parallel to V_{o1}. This results in improved efficiency and stability.

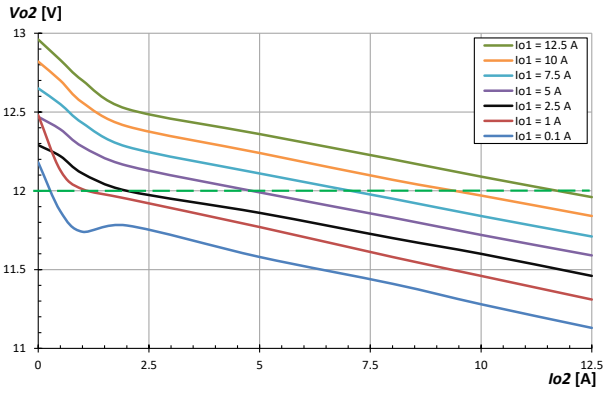

Fig. 6a
Models LR2320: V_{o2} versus I_{o2} with various I_{o1}

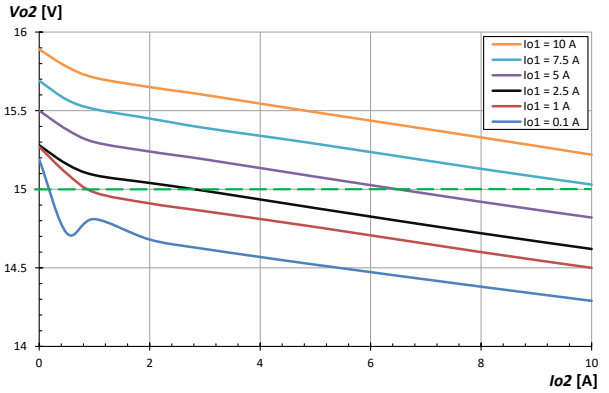

Fig. 6b
Models LR2540: V_{o2} versus I_{o2} with various I_{o1}

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AUXILIARY FUNCTIONS

Inhibit for Remote On/Off

The outputs may be enabled or disabled by means of a logic signal (TTL, CMOS, etc.) applied between the inhibit pin 18 (i) and pin 10 or 8 (Vo1–). In systems with several converters, this feature can be used to control the activation sequence of the converters. If the inhibit function is not required, connect the inhibit pin 18 with pin 10 or 8 (Vo1–).

The inhibit disables the DC-DC converter immediately, without respecting the hold-up time. The input section of the converter is not disabled.

Note: If pin 18 is not connected, the outputs are disabled.

Table 5: Inhibit characteristics

Characteristics			Conditions	min	typ	max	Unit
V_{inh}	Inhibit voltage	V_o = on	$V_{i\,min} - V_{i\,max}$	-10		0.8	V
		V_o = off		2.4		50	
I_{inh}	Inhibit current		V_{inh} = 0			-600	µA
t_r	Rise time				40		ms
t_d	Delay time				5		
t_f	Fall time		Depending on I_o				

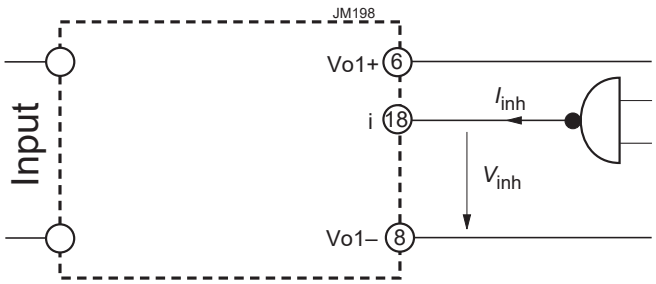

Fig. 7
Definition of V_{inh} and I_{inh}.

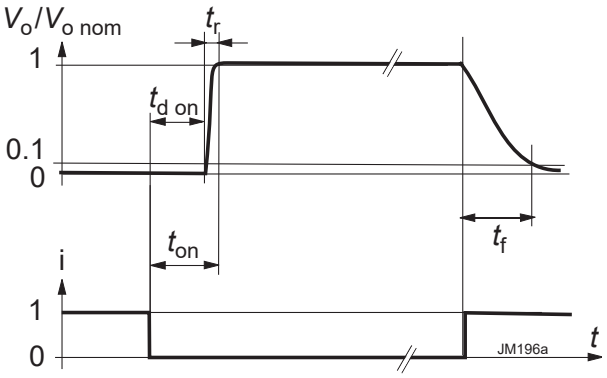

Fig. 8
Output response as a function of inhibit control

Output Voltage Adjust

As a standard feature, the converters offer an adjustable output voltage. The control input R (pin 16) accepts either a control voltage V_{ext} or a resistor R_{ext} to adjust the output voltage. When input R is not connected, the output voltage is set to $V_{o\,nom}$.

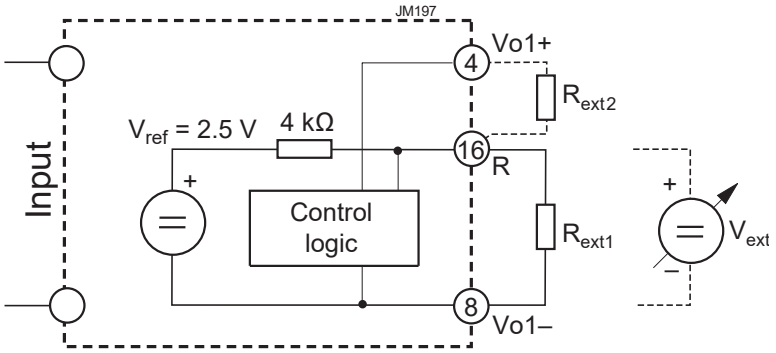

Fig. 9
Output voltage adjustment

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a) Adjustment by means of an **external control voltage V_{ext}** between pin 16 (R) and pin 10 or 8 (Vo1–):

The control voltage range is 0.75 V to 2.85 V and allows for an adjustment in the range of approx. 50 – 110 % of $V_{o\,nom}$.

$$V_{ext} \approx \frac{V_o \bullet 3.5\ V}{V_{o\,nom}} - 1$$

Caution: Applying an external control voltage >3 V may damage the converter.

b) Adjustment by means of an **external resistor**:

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

either: between pin 16 (R) and pin 10 or 8 (Vo1–) to adjust the output voltage in the range of approx. 50 – 100 % of $V_{o\,nom}$.

$$R_{ext1} \approx 4\ k\Omega \bullet \frac{V_o}{V_{o\,nom} - V_o}$$

or: between pin 16 (R) and pin 4 or 6 (Vo1+) to adjust the output voltage in the range of 100 – 110% of $V_{o\,nom}$.

$$R_{ext2} \approx 4\ k\Omega \bullet \frac{(V_o - 2.5\ V)}{2.5\ V \bullet (V_o/V_{o\,nom} - 1)}$$

Caution: To prevent the converter from damage, the value of R'_{ext} shall never be less than the value for increasing V_{o1} to 110% !

Notes:

– If the output voltages are increased above $V_{o\,nom}$ via R-input control or option T, the output currents should be reduced, so that $P_{o\,nom}$ is not exceeded.

– The second output of double-output models follows the voltage of the controlled main output.

Output Voltage Monitor

The output voltage monitor generates a logic “low” signal (NPN open-collector output) at the D-output (pin 20), when $V_{o1} \geq 0.96\ V_{o\,nom}$ and $\leq 1.04\ V_{o\,nom}$ (typ. values). Then, a green LED (Out OK) at the frontplate is illuminated. If the output voltage is adjusted by the R-input, the trigger levels are corrected accordingly.

At low D-output, I_D should be ≤ 50 mA. If the D-output is high (open collector), V_D should be ≤ 50 V.

Note: Output overvoltage activates a latch; see *Output Protection*.

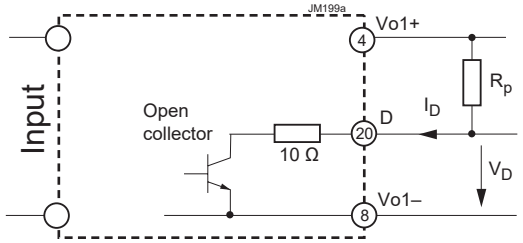

Fig. 10
Output voltage monitor

LED Indicators

Two green indicators are visible at the front plate:

- Out OK; see *Output Voltage Monitor*
- In OK. This signal is activated, when V_i is in range and the converter is not disabled by the inhibit signal.

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Battery Charging / Temperature Sensor

All converters with an R-input are suitable for battery charger application. For optimal battery charging and life expectancy of the battery an external temperature sensor can be connected to the R-input. The sensor is mounted as close as possible to the battery and adjusts the output voltage according to the battery temperature.

Depending upon cell voltage and the temperature coefficient of the battery, different sensor types are available, see *Accessories*.

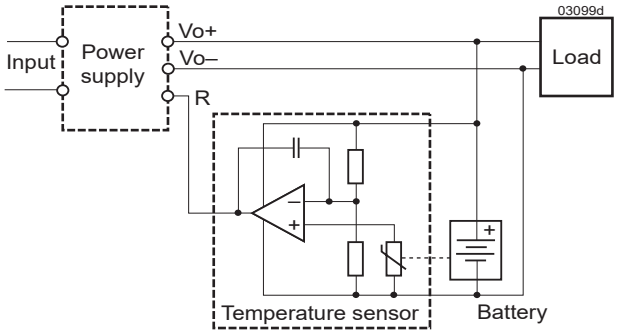

Fig. 11
Connection of a temperature sensor

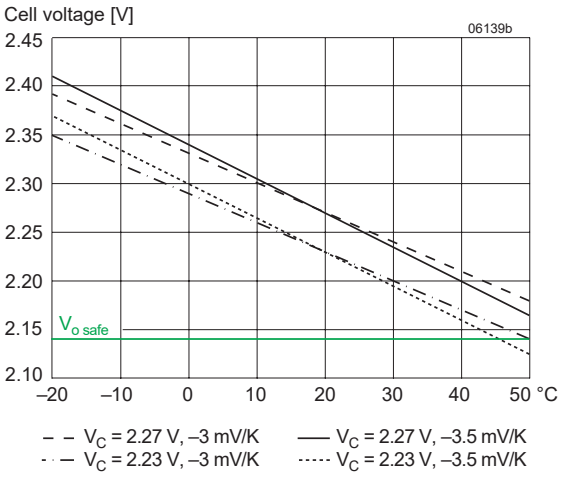

Fig. 12
Trickle charge voltage versus temperature for defined temperature coefficient. $V_{o\ nom}$ is the output voltage with open R-input.

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ELECTROMAGNETIC COMPATIBILITY (EMC)

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

Electromagnetic Immunity

Table 6: Electromagnetic immunity (type tests). Corresponds or Exceeds EN 50121-3-2:2016, EN 50121-4:2016 and AREMA

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	contact discharge	±6000 V_p	1/50 ns	330 Ω 150 pF	10 pos. & 10 neg. discharges	yes	A
			air discharge	±8000 V_p					
Electromagnetic field	IEC/EN 61000-4-3	x	antenna	20 V/m	AM 80% / 1 kHz	N/A	80 – 800 MHz	yes	A
			antenna	20 V/m	AM 80% / 1 kHz	N/A	800 – 1000 MHz	yes	A
				20 V/m			1400 – 2000 MHz		
				5 V/m			2000 – 2700 MHz		
				3 V/m			5100 – 6000 MHz	yes	A
Electrical fast transients / burst	IEC/EN 61000-4-4	3	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	i/c	±2000 V_p	1.2 / 50 µs	12Ω / 9µF	5 pos. & 5 neg. surges per coupling mode	yes	A
			i/c, +i/–i [3]	±1000 V_p		12Ω /9 µF			B
			+i/–i	±1000 V_p		2Ω /18 µF			A
Conducted disturbances	IEC/EN 61000-4-6	3	i, o, signal wires	10 VAC (140 dBµV)	AM 80% / 1 kHz	150 Ω	0.15 – 80 MHz	yes	A
Power frequency magnetic field	IEC/EN 61000-4-8	3	-	300 A/m	0 to 50 Hz		60 s in all 3 axes	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] AREMA requirement of Internal exposure class

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Electromagnetic Emissions

All models comply with Class A Group 1 according to EN 55011 / EN 55032 for conducted and radiated emissions.

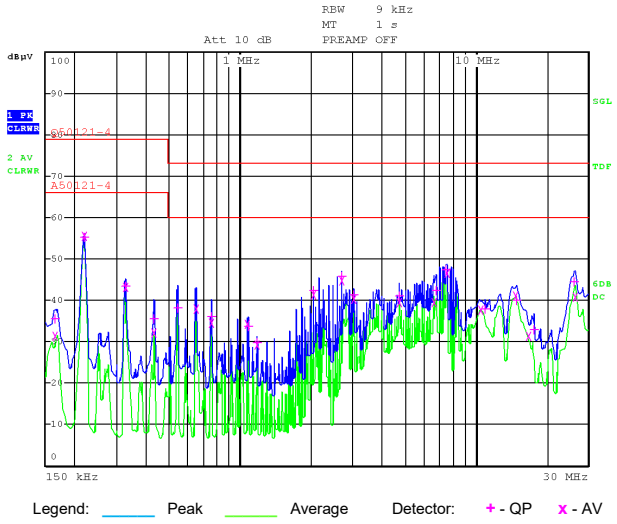

Fig. 15a
Typ. conducted emissions (peak/quasipeak and average) at the input according to EN 55011/32, measured at V_i = 230 V and $I_{o\,nom}$ (LR2320-9).

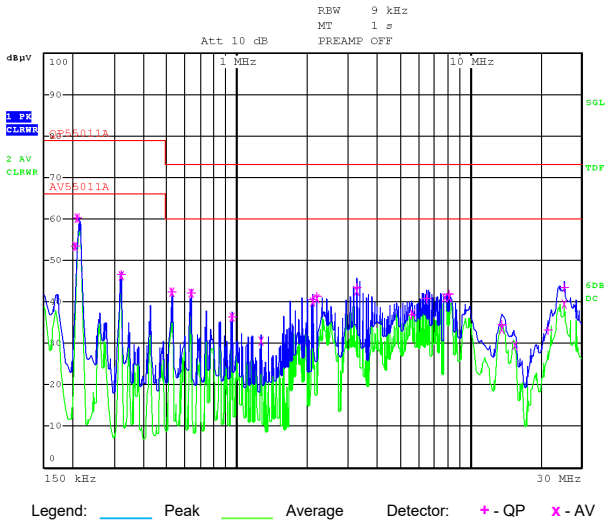

Fig. 15b
Typ. conducted emissions (peak/quasipeak and average) at the input according to EN 55011/32, measured at V_i = 230 V and $I_{o\,nom}$ (LRP2320-9).

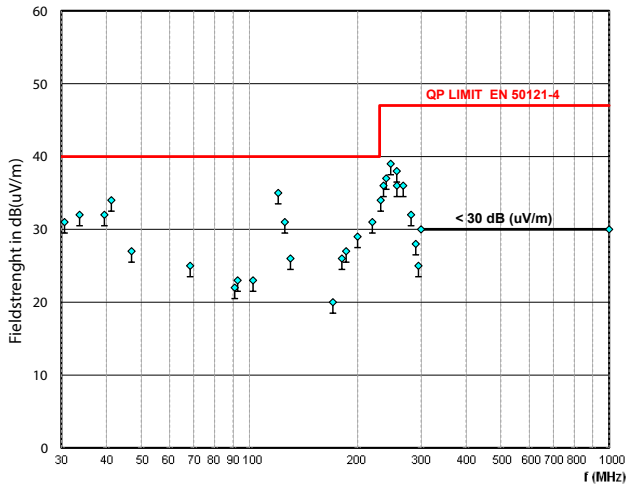

Fig. 16a
Typ. radiated emissions accord. to EN 55011/32, antenna 10 m distance, measured at V_i = 230 V and $I_{o\,nom}$ (LR2320-9).

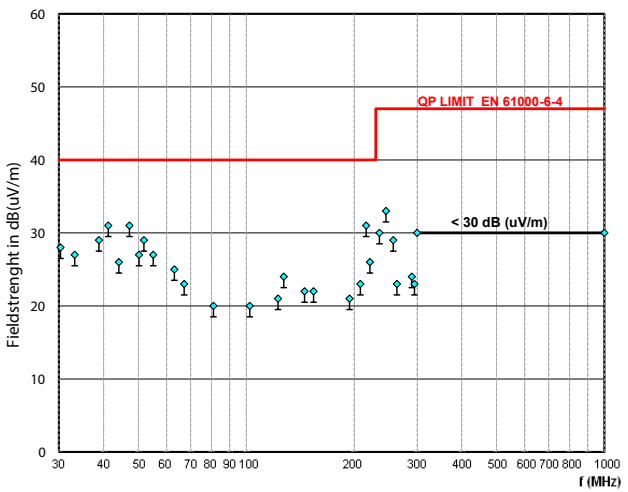

Fig. 16b
Typ. radiated emissions accord. to EN 55011/32, antenna 10 m distance, measured at V_i = 230 V and $I_{o\,nom}$ (LRP2320-9).

Table 7: Electromagnetic Emission Tests

Phenomenon	Standard	Test procedure	In operation	Result Class
Harmonic currents	IEC/EN 61000-3-2	$V_{i\,nom}$, $I_{o\,nom}$	yes	A
Voltage fluctuation and flicker	IEC/EN 61000-3-3	$V_{i\,nom}$, $I_{o\,nom}$	yes	Pass

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IMMUNITY TO ENVIRONMENTAL CONDITIONS

Table 8: Mechanical and climatic stress

Test method		Standard	Test Conditions		Status
Cab	Damp heat steady state	IEC/EN 60068-2-78 MIL-STD-810D section 507.2	Temperature:	40 $^{\pm 2}$ °C	Converter not operating
			Relative humidity:	93 $^{+2/-3}$ %	
			Duration:	56 days	
Db	Cyclic damp heat test	EN 50155:2017, clause 13.4.7 IEC/EN 60068-2-30	Temperature:	55 °C and 25 °C	Converter not operating
			Cycles (respiration effect)	2	
			Duration:	2x 24 h	
Be	Dry heat test steady state	EN 50155:2017, clause 13.4.5 IEC/EN 60068-2-2	Temperature:	70 °C	Converter operating
			Duration:	6 h	
Ad	Low temperature start-up test	EN 50155:2017, clause 13.4.4 IEC/EN 60068-2-1	Temperature, duration:	-40 °C, 2 h	Converter not operating
			Performance test:	+25 °C	
Ka	Salt mist test sodium chloride (NaCl) solution	EN 50155:2017, clause 13.4.10 IEC/EN 60068-2-11 class ST2	Temperature:	35 $^{\pm 2}$ °C	Converter not operating
			Duration:	48 h	
Fh	Random vibration broad band (digital control) & guidance	IEC/EN 60068-2-64	Acceleration spectral density:	0.05 g_n^2/Hz	Converter operating
			Frequency band:	8 – 500 Hz	
			Acceleration magnitude:	4.9 $g_{n\ rms}$	
			Test duration:	1.5 h (0.5 h in each axis)	
Fc	Vibration (sinusoidal)	IEC/EN 60068-2-6 MIL-STD-810D section 514.3	Acceleration amplitude:	0.35 mm (10 – 60 Hz) 5 g_n = 49 m/s^2 (60 - 2000 Hz)	Converter operating
			Frequency (1 Oct/min):	10 – 2000 Hz	
			Test duration:	7.5 h (2.5 h in each axis)	
-	Vibration	AREMA Part. 11.5.1 class B, C, D, E, I, J	Displacement amplitude:	0.3" (5 – 10 Hz) 0.1" (5 – 20 Hz)	Converter operating
			Acceleration amplitude:	2 g_n = 19.6 m/s^2 (10 - 200 Hz)	
			Frequency (1 Oct/min):	5 – 200 Hz	
			Test duration:	12 h (4 h in each axis)	
Ea	Shock (half-sinusoidal)	IEC/EN 60068-2-27 MIL-STD-810D section 516.3	Acceleration amplitude:	50 g_n = 490 m/s^2	Converter operating
			Bump duration:	11 ms	
			Number of bumps:	18 (3 in each direction)	
-	Shock	EN 50155:2017 clause 13.4.11, EN 61373 sect. 10, class B, body mounted [1]	Acceleration amplitude:	5.1 g_n	Converter operating
			Bump duration:	30 ms	
			Number of bumps:	18 (3 in each direction)	
-	Mechanical shock	AREMA Part. 11.5.1 class B, C, D, E, I, J	Acceleration amplitude:	10 g_n = 98 m/s^2	Converter operating
			Bump duration:	11 ms	
			Number of bumps:	18 (3 in each direction)	
-	Simulated long life testing at increased random vibration levels	EN 50155:2017 clause 13.4.11.2, EN 61373 sect. 8 and 9, class B, body mounted [1]	Acceleration spectral density:	0.02 g_n^2/Hz	Converter operating
			Frequency band:	5 – 150 Hz	
			Acceleration magnitude:	0.8 $g_{n\ rms}$	
			Test duration:	15 h (5 h in each axis)	

[1] Body mounted = chassis of a railway coach

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Temperatures

Table 9: Temperature specifications, valid for an air pressure of 800 – 1200 hPa (800 – 1200 mbar)

Model			-9			Unit
Characteristics		Conditions	min	typ	max	
T_A	Ambient temperature	Converter operating	- 40		71 [1]	° C
T_C	Case temperature		- 40		95 [1,2]	
T_S	Storage temperature	Not operating	- 55		85	

[1] See *Thermal Considerations*.

[2] Overtemperature lockout at T_C >95 °C. (An NTC resistor on primary and secondary heatsink).

Reliability

Table 10: MTBF

Reliability prediction standard	Model	MTBF
According to Siemens SN 29500 2013-07	LR2320-9	806 000

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MECHANICAL DATA

Dimensions in mm. The converters are designed to be inserted into a 19” rack, 160 mm long, according to IEC 60297-3.

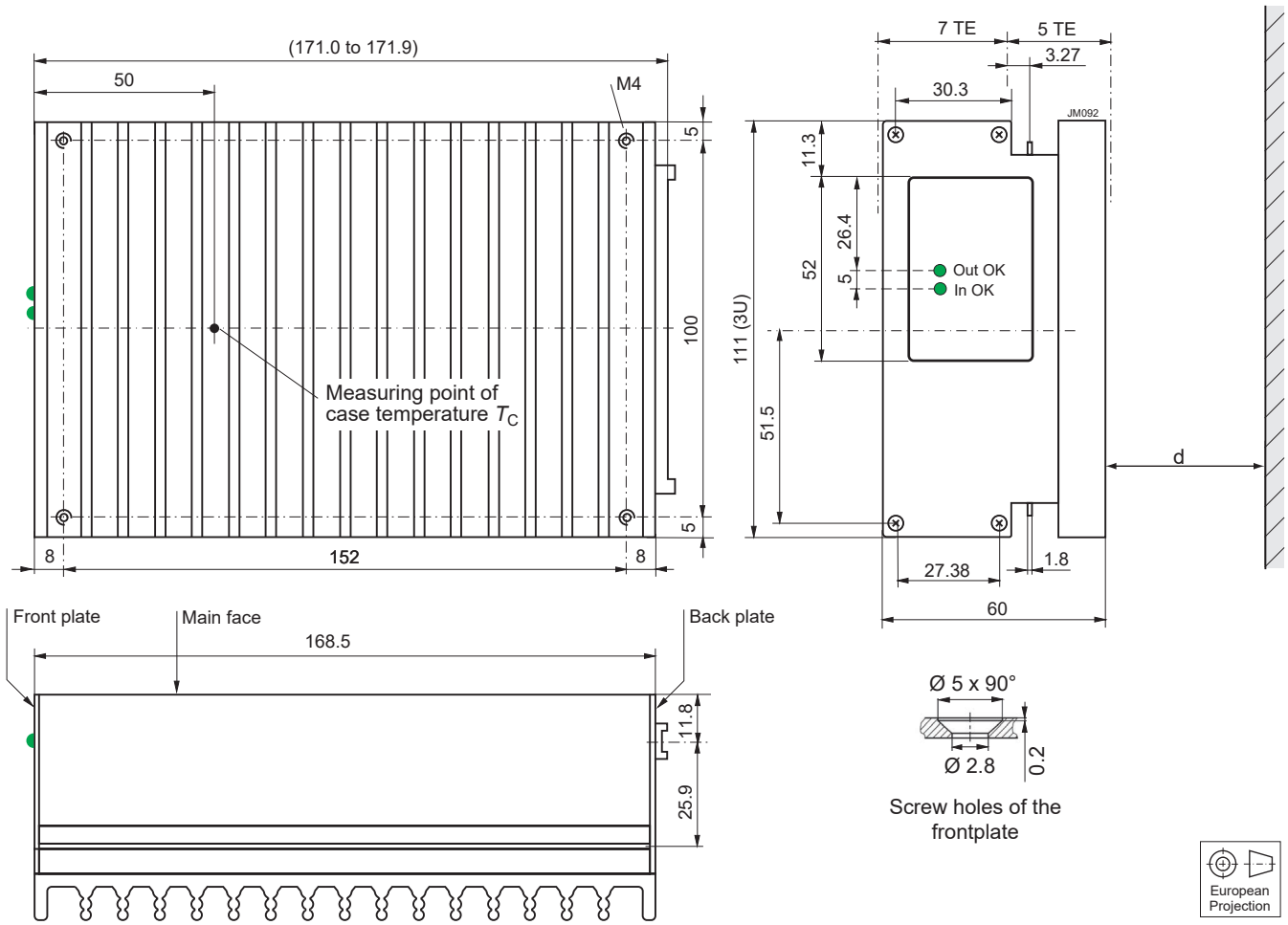

Fig. 17
Aluminum case of LR models with heat sink; black finish (EP powder coated); weight approx. 1.5 kg

Notes:

– d ≥ 15 mm, recommended minimum distance to next part in order to ensure proper air circulation at full output power.

– free air location: the converter should be mounted with fins in a vertical position to achieve maximum airflow through the heat sink.

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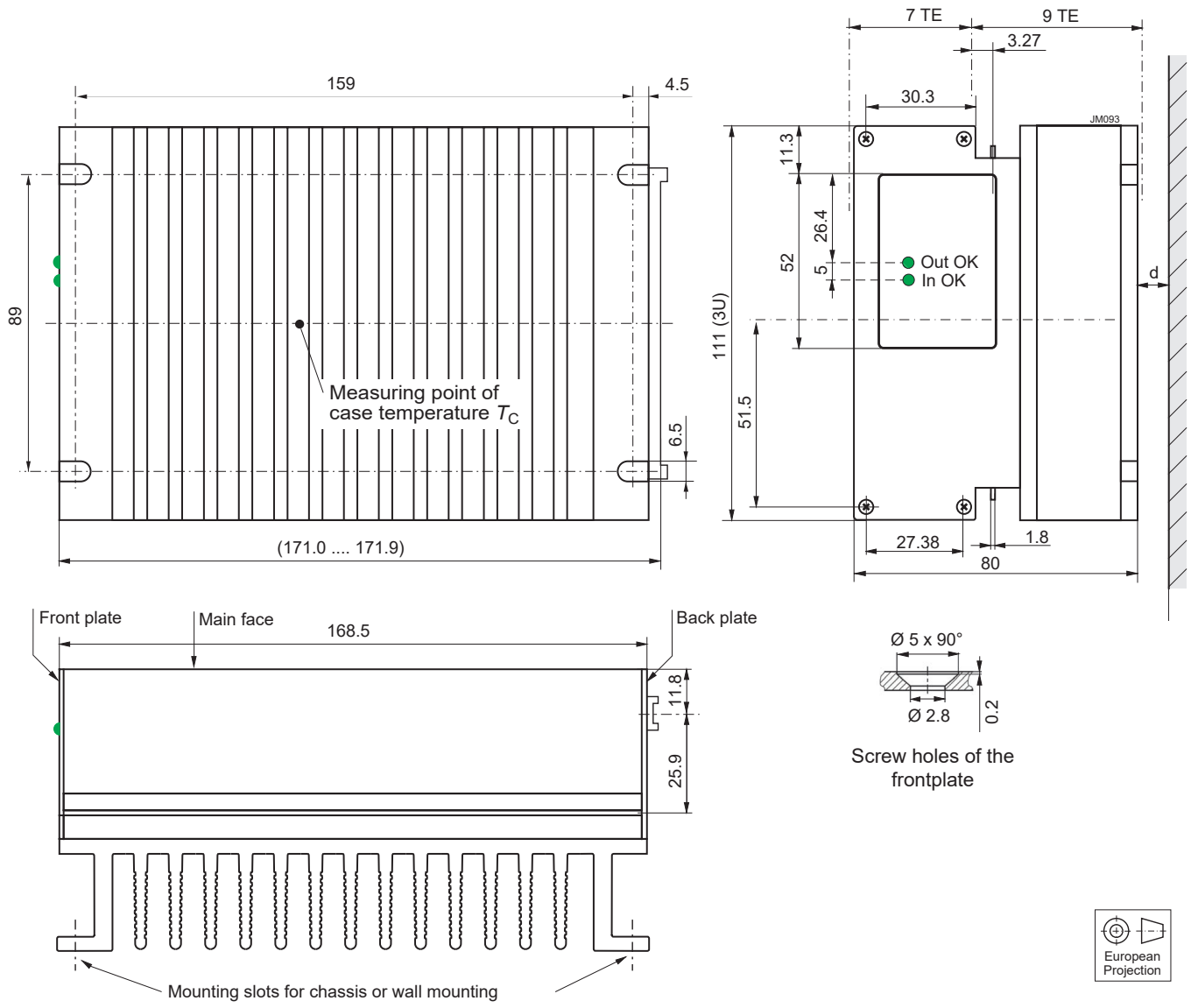

Fig. 18
Aluminum case of LRP models with heat sink; black finish (EP powder coated); weight approx. 1.8 kg

Notes:

– d ≥ 15 mm, recommended minimum distance to next part in order to ensure proper air circulation at full output power.

– free air location: the converter should be mounted with fins in a vertical position to achieve maximum airflow through the heat sink.

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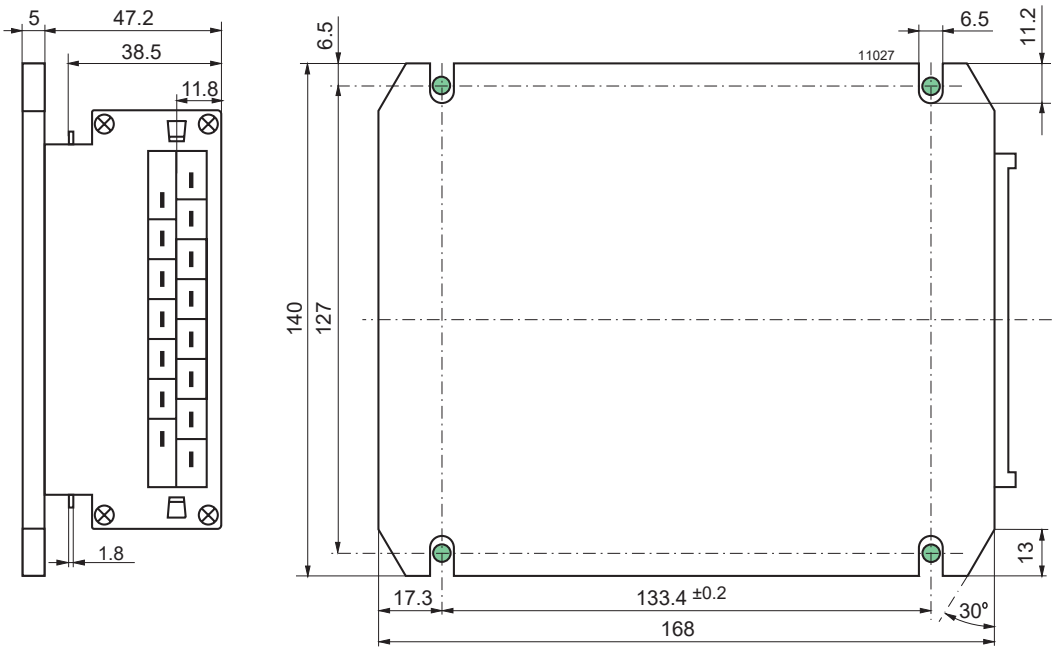

Fig. 19
Option B: Aluminum case S with large cooling plate; black finish (EP powder coated).
Suitable for front mounting.
Total weight approx. 1.5 kg

Note: Long case with option B2, elongated by 60 mm for 220 mm rack depth, is available on request (no LEDs, no test sockets).

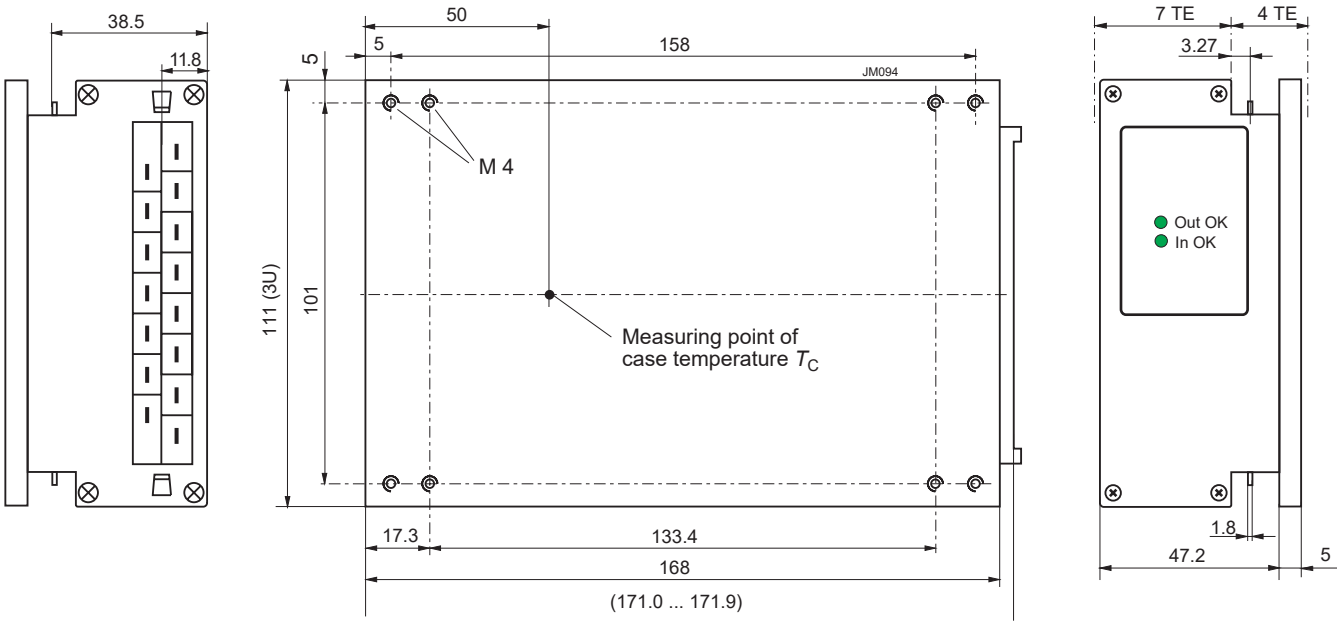

Fig. 20
Option B1: Aluminum case S with small cooling plate; black finish (EP powder coated).
Suitable for mounting with access from the backside.
Total weight approx. 1.4 kg.

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SAFETY AND INSTALLATION INSTRUCTIONS

Connector Pin Allocation

The connector pin allocation table defines the electrical potentials and the physical pin positions on the H15 connector. The protective earth is connected by a leading pin (no. 24), ensuring that it makes contact with the female connector first.

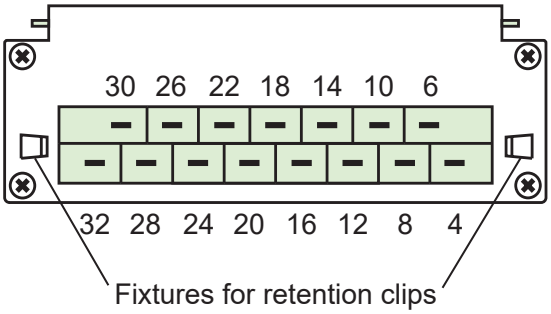

Fig. 21
View of module's male connector

Table 11: Pin allocation

Pin No.	Name	Function
4	Vo1+	Positive Output 1
6	Vo1+	Positive Output 1
8	Vo1-	Negative Output 1
10	Vo1-	Negative Output 1
12	Vo2+	Positive Output 2
14	Vo2-	Negative Output 2
16	R	Output voltage adjust
18	i	Inhibit
20	D	Out OK
22	T	Current share
24 [1]	⏚	Protection earth PE and case
26 + 28	N~	Neutral line
30 + 32	L~	Phase line

[1] Leading pin (pre-connecting)

Installation Instructions

The 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.

Connection to the system shall be made via the female connector H15; see *Accessories.* Other installation methods may not meet the safety requirements.

Pin no. 24 (⏚) is connected with the case. For safety reasons it is essential to connect this pin reliably to protective earth.

Notes:

– Pin 18 (inhibit) must be connected to pin 8 / 10 (Vo1–) to enable the converter.
– Do not open the converter, or warranty will be invalidated.
– If the second output is not used, connect it parallel with the main output.

Make sure that there is sufficient airflow available for convection cooling and verify it by measuring the case temperature T_C, when the converter is installed and operated in the end-use application; see *Thermal Considerations.*

Ensure that a converter failure (e.g. an internal short-circuit) does not result in a hazardous condition.

Standards and Approvals

The converters are safety-approved to UL/CSA 62368-1 and IEC/EN 62368-1.

The converters correspond to Class I equipment (case connected to ground). They have been evaluated for:

- Building-in
- Basic insulation between input and case based on 250 VA; basic insulation between outputs and case; double or reinforced insulation between input and outputs
- Functional insulation between outputs
- Overvoltage category II
- Pollution degree 2 environment
- Max. altitude: 2000 m
- The converters fulfil the requirements of a fire enclosure.

The output voltage is considered as ES1. The converters are subject to manufacturing surveillance in accordance with the above mentioned safety standards and with ISO 9001:2015, IRIS ISO/TS 22163:2017 certified quality and business management system. CB-scheme is available on request.

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Railway Application and Fire Protection

The converters have been designed by observing the railway standards EN 50155 and EN 50121-4. All boards are coated with a protective lacquer.

The converters comply with EN 45545-1, EN 45545-2 (2016), if installed in a technical compartment or cabinet.

Protection Degree and Cleaning Liquids

In order to avoid possible damage, any penetration of cleaning fluids has to be prevented, since the power supplies are not hermetically sealed.

The protection degree is IP 40, provided that the female connector is fitted to the converter.

Isolation and Protective Earth

The electric strength test is performed in the factory as routine test according to EN 62911 and IEC/EN 62368-1 and should not be repeated in the field. The company will not honor any warranty claims resulting from incorrectly executed electric strength field tests. The resistance between case and earth pin (< 0.1 Ω) is tested as well.

Table 12: Isolation

Characteristics		Input to Case + Output(s)	Output(s) to Case and Input	Output 1 to Output 2	Unit
Electric strength test	Factory test 10 s	2.84 [1]	4.3	0.5	kVDC
	AC test voltage equivalent to factory test	2.0 [1]	3.0	0.3	kVAC
Insulation resistance at 500 VDC		>300	>300	>300	MΩ
Creepage distances		≥ 3.5 [2]	≥ 4.5	---	mm

[1] According to EN 62911 and IEC/EN 62368-1, subassemblies connecting input to output are pre-tested with 5.6 kVDC or 4 kVAC.
[2] Input to outputs: 7.0 mm

DESCRIPTION OF OPTIONS

F0, F2 Fuse Options

The converters exhibit a fuse in the input phase line (L, pins 30 and 32), see Table 3.

Option F0 means that there is no fuse incorporated.

Option F2 (fuses in both input lines) is required for operation with AC in several countries, but especially if the converter is operated between phases, or if the neutral line cannot be allocated (e.g., for German “Schuko” connectors).

Table 3 shows the type of the fuse.

B, B1 Cooling Plates

Where a cooling surface is available, we recommend the use of a cooling plate instead of the standard heat sink. The mounting system should ensure that the maximum case temperature $T_{C\,max}$ is not exceeded. The cooling capacity is calculated by (η see *Model Selection)*:

$$P_{Loss} = \frac{(100\,\% - \eta)}{\eta} \bullet V_o \bullet I_o$$

For the dimensions of the cooling plates; see *Mechanical Data*.

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ACCESSORIES

A variety of electrical and mechanical accessories are available including:

– Front panels for 19” DIN-rack: Schroff or Intermas, 12 or 16TE / 3U; see fig. 22.
– Mating H15 connectors with screw, solder, faston, or press-fit terminal; see fig. 23.
– Coding clips for connector coding HZZ00202
– Pair of connector retention clips HZZ01209-G; see fig.25
– Connector retention brackets HZZ01216-G (CRB-HKMS)
– Cable hood for H15 connectors:
  - HZZ00141-G, screw version
  - HZZ00142-G, use with retention brackets HZZ01218-G
  - HZZ00143-G, metallic version providing fire protection
– Cage clamp adapter HZZ00144-G; see fig. 26.
– DIN-rail mounting assembly HZZ0615-G (DMB-K/S)
– Wall-mounting plate K02 (HZZ01213-G) for models with option B1
– Additional external input and output filters
– Different battery sensors S-KSMH... for using the converter as a battery charger. Different cell characteristics can be selected; see fig. 30, table 12, and *Battery Charging/Temperature Sensors.*

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

Fig. 22
Different front panels

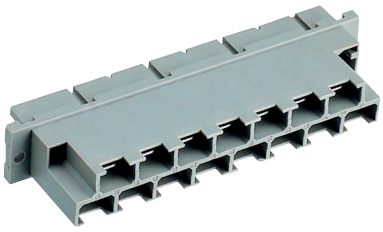

Fig. 23
Different mating connectors

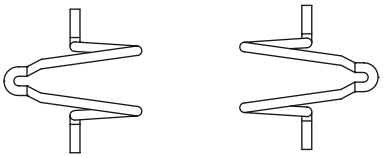

Fig.24
Connector retention clips to fasten the H15 connector to the rear plate; see fig. 24. HZZ01209-G consists of 2 clips.

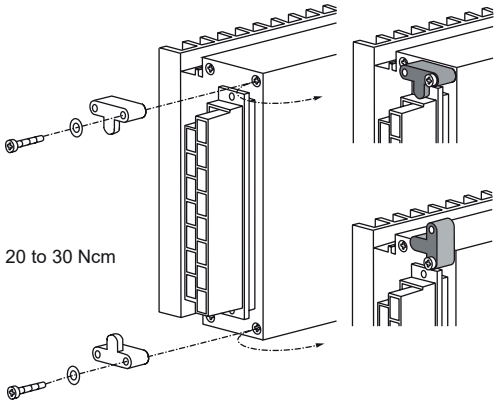

Fig. 25
Connector retention brackets HZZ01216-G (CRB-HKMS)

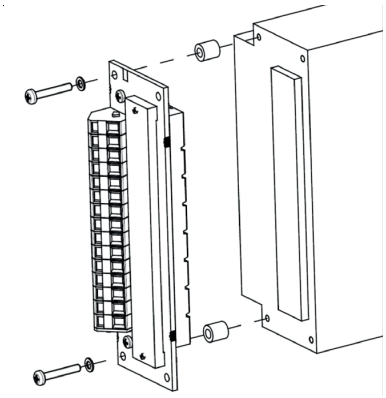

Fig. 26
Cage clamp adapter HZZ00144-G

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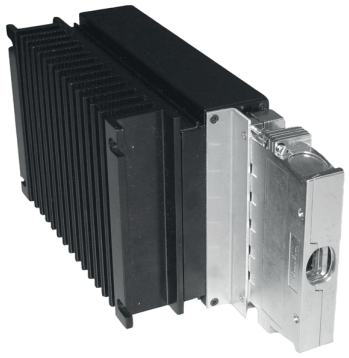

Fig. 27
Different cable hoods

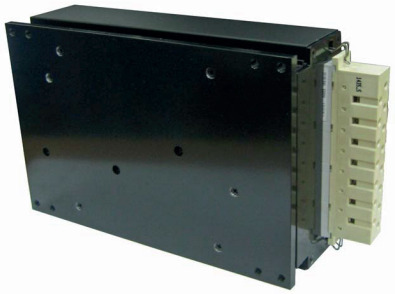

Fig. 28
Chassis- or wall-mounting plate HZZ01213-G (Mounting plate K02)

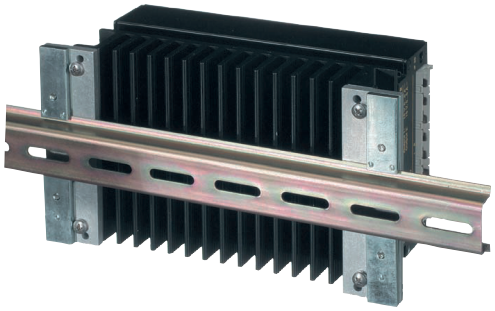

Fig. 29
DIN-rail mounting assembly HZZ00615-G (DMB-K/S)

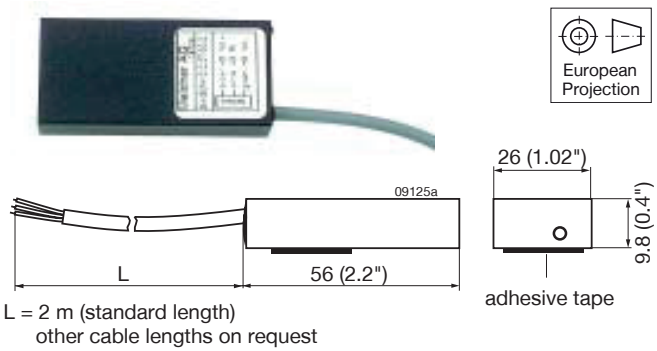

Fig. 30
Battery temperature sensor

Table 13: Battery temperature sensors

Battery voltage nom. [V]	Sensor type	Cell voltage [V]	Cell temp. coefficient [mV/K]	Cable length [m]
12	S-KSMH12-2.27-30-2	2.27	–3.0	2
12	S-KSMH12-2.27-35-2	2.27	–3.5	2
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

Note: Other temperature coefficients and cable lengths are available on request.

NUCLEAR AND MEDICAL APPLICATIONS - These products are not designed or intended for use as critical components in life support systems, equipment used in hazardous environments, or nuclear control systems.

TECHNICAL REVISIONS - The appearance of products, including safety agency certifications pictured on labels, may change depending on the date manufactured. Specifications are subject to change without notice.

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