

Features

- RoHS-compliant
- Class I equipment
- Universal input voltage range
- Inrush current limitation
- 2 isolated adjustable outputs
- No load, overload, and short-circuit proof
- Rectangular current limiting characteristic
- Inhibit function
- Parallel operation with active current sharing
- Hold-up time 20 ms
- Designed according to EN 50155, EN 50121-4, AREMA
- Fire & smoke according to EN 45545.
- Immunity according to IEC 61000-4-2, -3, -4, -5, -6, -8, -9
- ALL PCB boards protected by lacquer
- Very high reliability

Safety-approved according to IEC/EN 60950-1, UL/CSA 60950-1 2nd Ed.



Description

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. All boards are coated with a protective lacquer.

Preliminary

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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 $P_{o\ nom}$ [W]	Input voltage $V_{i\ cont}$ [VAC]	η_{110}^1		η_{230}^2		Model	Opt.
$V_{o\ nom}$ [V]	$I_{o\ nom}$ [A]	$V_{o\ nom}$ [V]	$I_{o\ nom}$ [A]			min. [%]	typ. [%]	min. [%]	typ. [%]		
12	10	12	10	240	90 to 264	90			LR2320-9RG LRP2320-9RG LR2540-9RG LRP2540-9RG LR2880-9RG LRP2880-9RG	F0, F2, B, B1	
12	12.5	12	12.5	300							
15	8	15	8	240							
15	10	15	10	300							
48	2.2	48	2.2	211							
48	2.6	48	2.6	250							

¹ Efficiency at $T_A = 25\ ^\circ\text{C}$, $V_i = 110\ \text{VAC}$, $I_{o\ nom}$, $V_{o\ nom}$

² Efficiency at $T_A = 25\ ^\circ\text{C}$, $V_i = 230\ \text{VAC}$, $I_{o\ nom}$, $V_{o\ nom}$

Part Number Description

	LR 2 3 20 -9 B1 G
Operating input voltage $V_{i\text{cont}}$ (continuously): 100 – 240 VAC	LR
Number of outputs	2, 7 ²
Nominal voltage of main output $V_{o1\text{nom}}$	
12 V	3
15 V	5
24 V ⁴	6
36 V	7
48 V	8
Other voltages ¹	9
Nominal voltage of tracking output V_{o2} ³	
12 V	20
15 V	40
24 V ⁴	60
36 V ⁴	70
48 V	80
Other specifications or additional features ¹	21 – 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
Cooling plate for long case 220 mm ²	B2 ²
RoHS-compliant for all 6 substances	G

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 Converters with 220 mm case (customer-specific models). Add 5000 to the model number!

³ The nominal voltages of both outputs are always equal.

⁴ Models not or not yet available

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

Example: LR2320-9B1G: AC-DC converter, operating input voltage range 90 to 264 VAC, 2 isolated outputs, each providing 12 V, 20 A, cooling plate B1, RoHS-compliant for all six substances.

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 (not models with $V_o = 2 \times 48\text{ V}$), 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 current limitation, the second output voltage will drop as well and vice versa.

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).

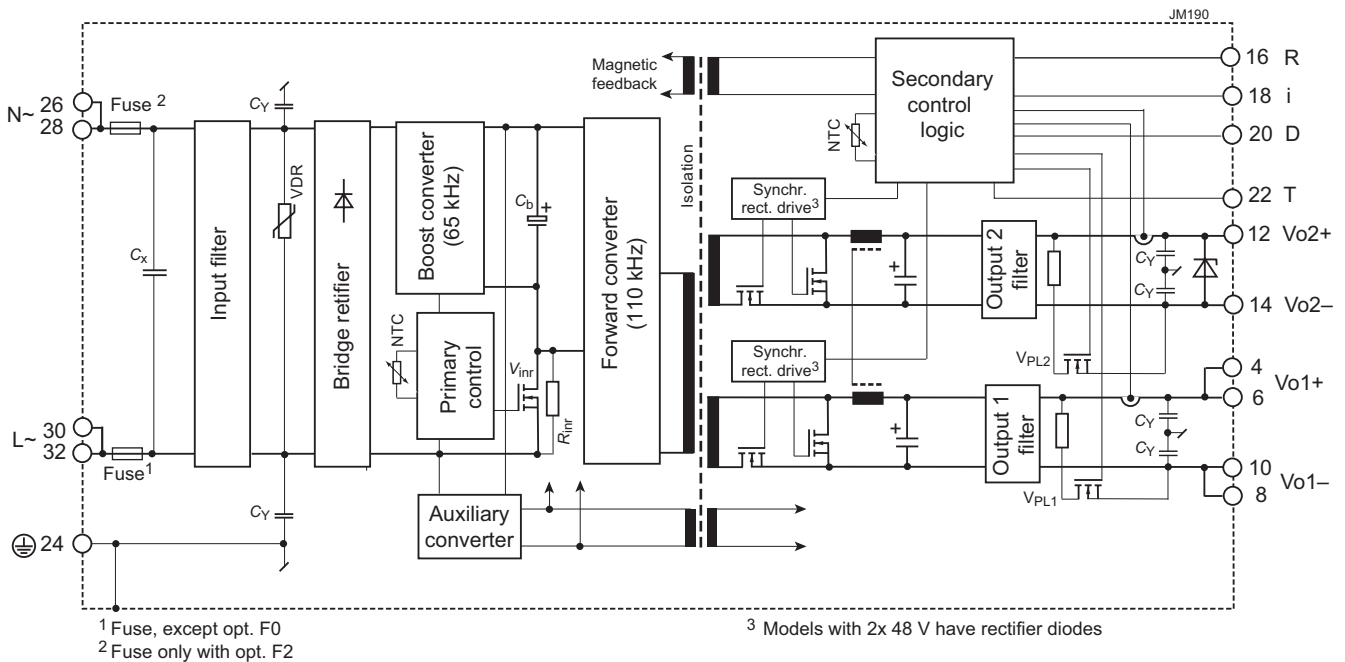


Fig. 1
 Block diagram

Electrical Input Data

General Conditions:

- $T_A = 25\text{ °C}$, unless T_C is specified.
- Pin 18 (i) connected to pin 14, pin 16 (R), pin 18 (D), and pin 22 (T) left open-circuit.

Table 2: Electrical input data

Input			LR			LRP			Unit
Characteristics		Conditions	min	typ	max	min	typ	max	
V_i	Rated input voltage range	$I_o = 0 - I_{o\text{ nom}}$ $T_C\text{ min to }T_C\text{ max}$	100		240	100		240	VAC ¹
$V_{i\text{ op}}$	Operating input voltage range		90		264	90		264	
$V_{i\text{ nom}}$	Nominal input voltage ¹	50 – 60 Hz		230		230			
I_i	Input current	$V_{i\text{ nom}}, I_{o\text{ nom}}$							A
P_{i0}	No-load input power	$V_{i\text{ min}} - V_{i\text{ max}}, I_o = 0$							W
$P_{i\text{ inh}}$	Idle input power	converter inhibited							
t_{hu}	Hold-up time	$V_i = 100\text{ VAC}, I_{o\text{ nom}}$	20			20			ms
C_b	Boost capacitance								μF
t_{on}	Start up time								ms
$V_{i\text{ abs}}$	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. For operation at other frequencies, contact the factory. Operation with DC input voltage is not specified and not recommended.

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.

A fuse mounted inside the converter in the phase line protects against severe defects. A second fuse in the neutral line may be necessary in certain applications; see *Options* and *Installation Instructions*.

Table 3: Fuse specification

Model	Fuse rating	Part no.
LR2320, LR2540	5 A, 250 V, slow, 5 × 20 mm	5TTP 5-R
LRP2320, LRP2540	6 A, 250 V, slow, 5 × 20 mm	5TTP 6-R
LR2880	4 A, 250 V, slow, 5 × 20 mm	5TTP 4-R
LRP2880	5 A, 250 V, slow, 5 × 20 mm	5TTP 5-R

Input Under-/Overvoltage Lockout

If the input voltage is below approx. 80 VAC or exceeds $V_{i\text{ op max}}$, an internally generated inhibit signal disables the outputs.

If V_i is below $V_{i\text{ min}}$, 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; see *Auxiliary Functions*.

Efficiency

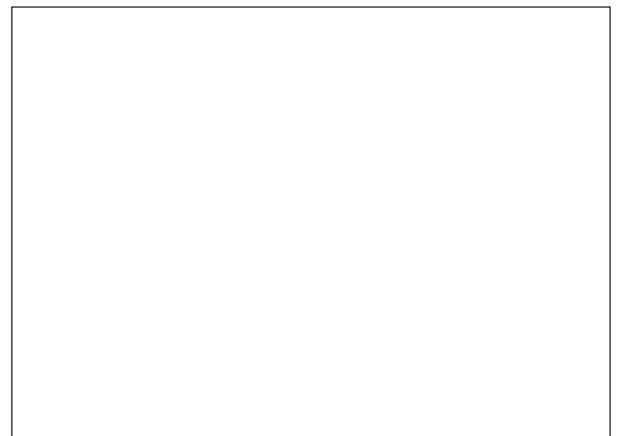


Fig. 2
 Efficiency versus V_i and I_o (LR2320, both outputs connected in series)

Electrical Output Data

- $T_A = 25\text{ °C}$, unless T_C is specified.
- Pin 18 (i) connected to pin 14, pin 16 (R), pin 18 (D), and pin 22 (T) left open-circuit.

Table 4a: Output data of LR2320 and LRP2320

Model		Conditions	LR2320 2 x 12 V			LRP2320 2 x 12 V			Unit		
Nom. output voltage			Output 1		Output 2	Output 1		Output 2			
Characteristics			min	typ	max	min	typ	max		min	typ
V_o	Output voltage	$V_{i\text{nom}}, 0.5 I_{o\text{nom}}$	11.93	12.0	12.07	12.0	1.93	12.0	12.07	12.0	V
$V_{o\text{BR}}$	Output protection (suppressor diode)	Output 2	--		14.4	15.9	--		14.4	15.9	
$I_{o\text{nom}}$	Output current nom.	$V_{i\text{min}} - V_{i\text{max}}$	10		10	12.5		12.5		A	
I_{o1L}, I_{o2L}	Output current limit ¹	$T_{C\text{min}} - T_{C\text{max}}$	10.5		10.5	13		13			
I_{o12L}	Output current limit ^{1 2}		21 ²		--	26 ²		--			
v_o	Output noise incl. spikes	$V_{i\text{nom}}, I_{o\text{nom}}$ BW = 20 MHz	60		60	60		60		mV _{pp}	
$V_{o\text{adj}}$	Adjustment by R-input ⁴	$V_{i\text{min}} - V_{i\text{max}}$	4.8	13.2 ¹	3	4.8	13.2 ¹	3		V	
$\Delta V_{o\text{u}}$	Static line/load regulation (total deviation of V_o)	$(0.1 - 1) I_{o\text{nom}}$	± 120		3	± 120		3		mV	
$V_{o\text{d}}$	Dynamic load regulat.	Voltage deviation ⁵	± 200		± 200	± 250		± 250			
$t_{o\text{d}}$			Recovery time ⁵	1		3	1		3		ms
$\alpha_{v\text{o}}$	Temperature coefficient of output voltage	$T_{C\text{min}} - T_{C\text{max}}$ $I_{o\text{nom}}$	0.02		--	0.02		--		%/K	

¹ If V_o is increased above $V_{o\text{nom}}$ through R-, sense, or T-input, the output currents should be reduced so that $P_{o\text{nom}}$ 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.

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

Model			LR2540 2 x 15 V						LRP2540 2 x 15 V						Unit			
Nom. output voltage			Output 1			Output 2			Output 1			Output 2						
Characteristics			Conditions			min	typ	max	min	typ	max	min	typ	max		min	typ	max
V_o	Output voltage		$V_{i\text{nom}}, 0.5 I_{o\text{nom}}$			14.91	15.0	15.09	15.0			14.91	15.0	15.09	15.0			V
$V_{o\text{BR}}$	Output protection (suppressor diode)		Output 2			--			20.9	23.1		--			20.9	23.1		
$I_{o\text{nom}}$	Output current nom.		$V_{i\text{min}} - V_{i\text{max}}$			8			8			9.6			9.6			A
I_{o1L}, I_{o2L}	Output current limit ¹		$T_{C\text{min}} - T_{C\text{max}}$			8.4			8.4			10.1			10.1			
I_{o12L}	Output current limit ^{1 2}					16.8 ²			--			19.7 ²			--			
v_o	Output noise incl. spikes		$V_{i\text{nom}}, I_{o\text{nom}}$ BW = 20 MHz			75			75			75			75			mV _{pp}
$V_{o\text{adj}}$	Adjustment by R-input ⁴		$V_{i\text{min}} - V_{i\text{max}}$ $(0.1 - 1) I_{o\text{nom}}$			6.0	17.25 ¹		3			6.0	17.25 ¹		3			V
$\Delta V_{o\text{u}}$	Static line/load regulation (total deviation of V_o)					± 150			3			± 150			3			mV
$v_{o\text{d}}$	Dynamic load regulat.	Voltage deviation ⁵	$V_{i\text{nom}}, 0.5 I_{o2\text{nom}}$ $I_{o1\text{nom}} \leftrightarrow 0.5 I_{o1\text{nom}}$ and after turn on			± 250			± 250			± 300			± 300			
$t_{o\text{d}}$		Recovery time ⁵				1			3			1			3			ms
α_{v_o}	Temperature coefficient of output voltage		$T_{C\text{min}} - T_{C\text{max}}$ $I_{o\text{nom}}$			0.02			--			0.02			--			%/K

¹ If the output voltages are increased above $V_{o\text{nom}}$ through R-input control, remote sensing, or option T, the output currents should be reduced accordingly so that $P_{o\text{nom}}$ 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.

Table 4c: Output data of LR2880 and LRP2880. General conditions as per table 4a

Model			LR2880 2 × 48 V						LRP2880 2 × 48 V						Unit
Nom. output voltage			Output 1			Output 2			Output 1			Output 2			
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	
V_o	Output voltage	$V_{i\text{nom}}, 0.5 I_{o\text{nom}}$	47.7	48.0	48.3	48.0			47.7	48.0	48.3	48.0			V
$V_{o\text{BR}}$	Output protection (suppressor diode)	Output 2	--			56.7	62.7		--			56.7	62.7		
$I_{o\text{nom}}$	Output current nom.	$V_{i\text{min}} - V_{i\text{max}}$	2.2			2.2			2.6			2.6			A
I_{o1L}, I_{o2L}	Output current limit ¹	$T_{C\text{min}} - T_{C\text{max}}$	2.3			2.3			2.65			2.65			
I_{o12L}	Output current limit ^{1 2}		4.6 ²			--			5.3 ²			--			
v_o	Output noise incl. spikes	$V_{i\text{nom}}, I_{o\text{nom}}$ BW = 20 MHz	240			240			240			240			mV _{pp}
$V_{o\text{adj}}$	Adjustment by R-input ⁴	$V_{i\text{min}} - V_{i\text{max}}$ (0.1 – 1) $I_{o\text{nom}}$	19.2	55.2 ¹		3		19.2	55.2 ¹		3			V	
$\Delta V_{o\text{u}}$	Static line/load regulation (total deviation of V_o)		±0.5			3			±0.5			3			
$v_{o\text{d}}$	Dynamic load regulat.	Voltage deviation ⁵ and after turn on	±0.8			±0.8			±1.0			±1.0			
$t_{o\text{d}}$			Recovery time ⁵	1			3			1			3		
α_{V_o}	Temperature coefficient of output voltage	$T_{C\text{min}} - T_{C\text{max}}$ $I_{o\text{nom}}$	0.02			--			0.02			--			%/K

¹ If the output voltages are increased above $V_{o\text{nom}}$ through R-input control, remote sensing, or option T, the output currents should be reduced accordingly so that $P_{o\text{nom}}$ 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.

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.

Hold-up Time

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

Output Protection

The 2nd output is 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_{OBR} 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 $V_{O\text{nom}}$ 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.

Notes:

- Not more than 5 converters should be connected in parallel.
- If several outputs are connected in series, the resulting voltage may exceed the SELV 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.

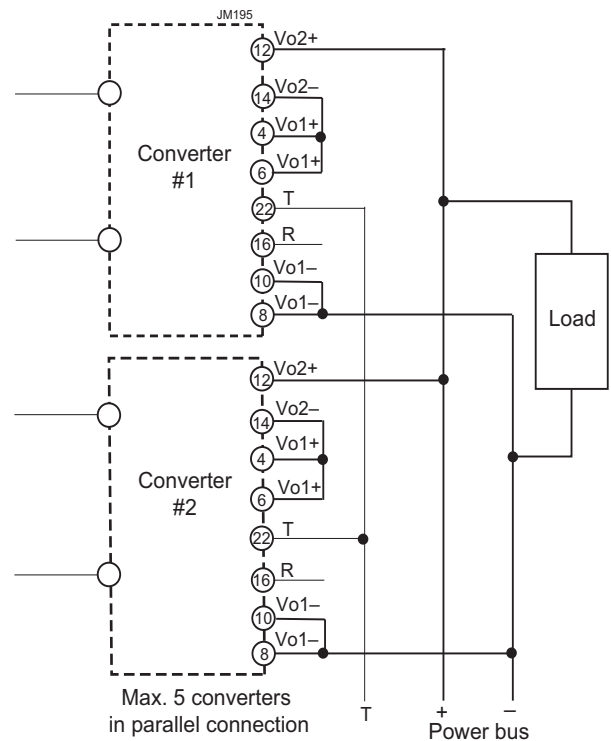


Fig. 3
 Parallel connection of double-output models with their outputs connected in series.
 T-pins and R-pins are referenced to $Vo1-$.

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 $V_{o\text{ nom}}$, 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.

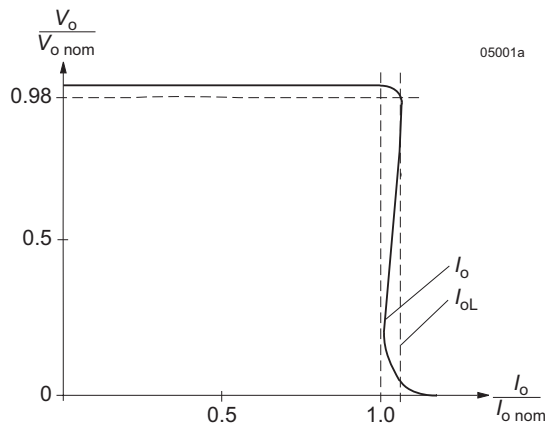


Fig. 4
Output characteristic V_o versus I_o (both outputs connected in parallel or in series)

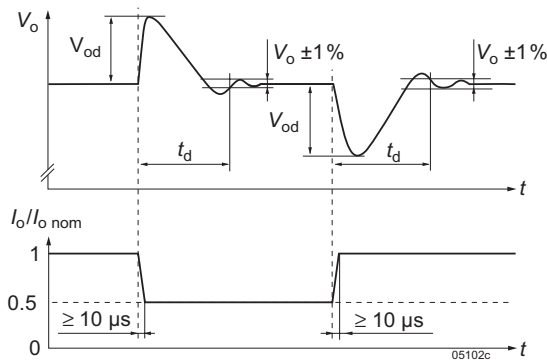


Fig. 5
Typical dynamic load regulation of V_o .

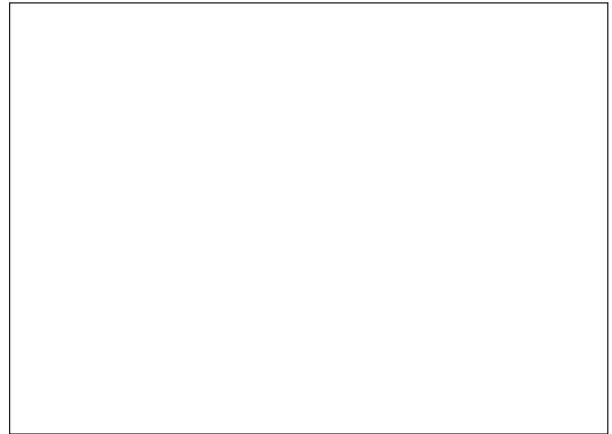


Fig. 6a
Models LR2320: V_{o2} versus I_{o2} with various I_{o1}

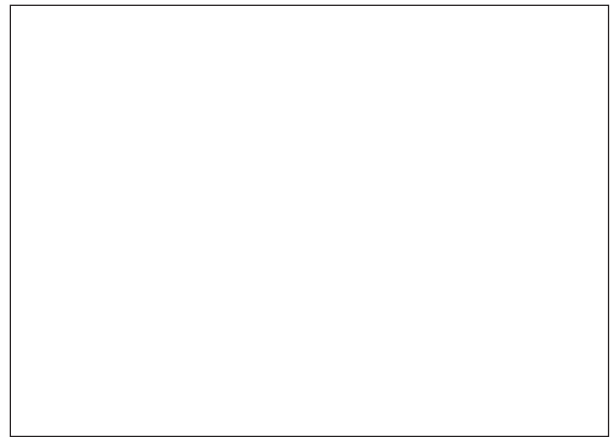


Fig. 6b
Models LR2880: V_{o2} versus I_{o2} with various I_{o1}

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.

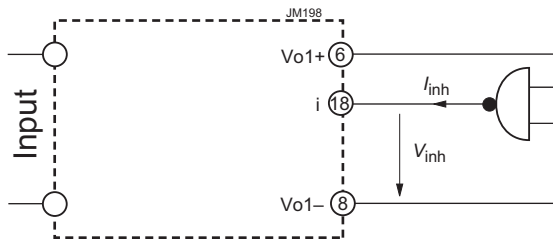


Fig. 7
 Definition of V_{inh} and I_{inh} .

Table 5: Inhibit characteristics

Characteristic		Conditions	min	typ	max	Unit
V_{inh}	Inhibit voltage	$V_o = \text{on}$	$V_{i \min} - V_{i \max}$	-10	0.8	V
		$V_o = \text{off}$		2.4	50	
I_{inh}	Inhibit current	$V_{inh} = 0$			-400	μA
t_r	Rise time			30		ms
t_d	Delay time					
t_f	Fall time	depending on I_o				

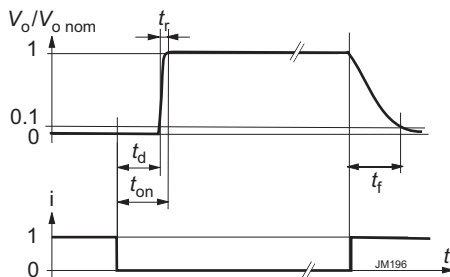


Fig. 8
 Output response as a function of inhibit control

Current Share Function

If the T-pins (22) of parallel-connected converters are linked together, the converters share the output current evenly. Refer to section *Parallel and Series Connection*.

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 $V_{o \text{ nom}}$.

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 1.0 – 2.75 V and allows for an adjustment in the range of approx. 40 – 110% of $V_{o \text{ nom}}$.

$$V_{ext} \approx \frac{V_o \cdot 2.5 \text{ V}}{V_{o \text{ nom}}}$$

Caution: Applying an external control voltage $>2.75 \text{ V}$ 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. 40 – 100% of $V_{o \text{ nom}}$.

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

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

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

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 $V_{o \text{ nom}}$ via R-input control, sense lines, or option T, the output currents should be reduced, so that $P_{o \text{ nom}}$ is not exceeded.
- The second output of double-output models follows the voltage of the controlled main output.

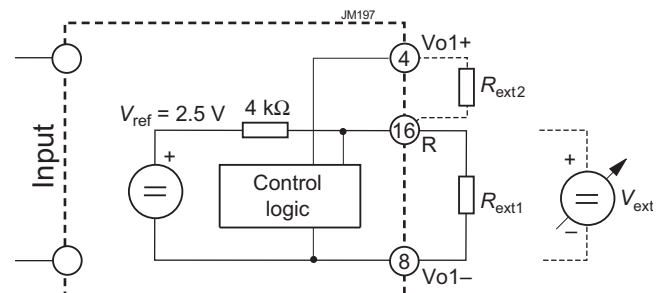


Fig. 9
 Output voltage adjustment

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*.

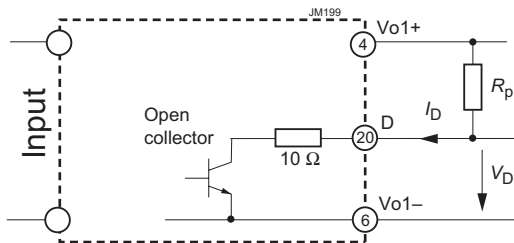


Fig. 10
Output voltage monitor

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.

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*.

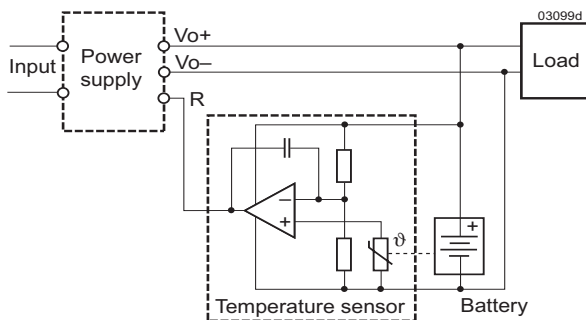


Fig. 11
Connection of a temperature sensor

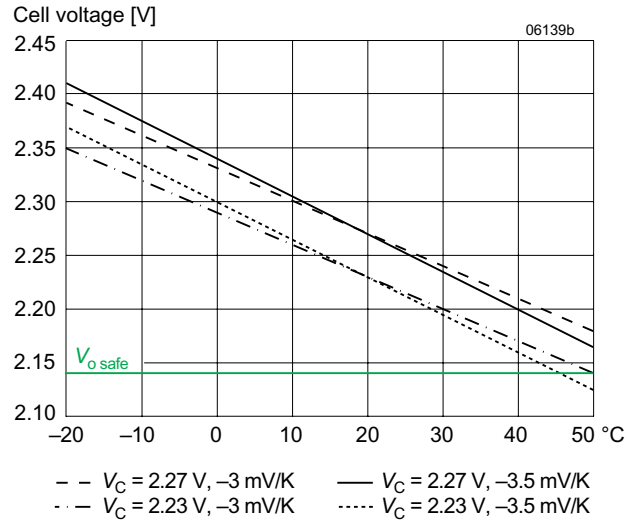


Fig. 12
Trickle charge voltage versus temperature for defined temperature coefficient. $V_{o\ nom}$ is the output voltage with open R-input.

Electromagnetic Compatibility (EMC)

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

Electromagnetic Immunity

Table 6: 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 ⁵	contact discharge	$\pm 6000 V_p$	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	A
			air discharge	$\pm 8000 V_p$					
Electromagnetic field	IEC / EN 61000-4-3	x ⁶	antenna	20 V/m	AM 80% /1 kHz	n.a.	80 – 800 MHz	yes	A
				20 V/m			800 – 1000 MHz		
				10 V/m			1400 – 2000 MHz		
				5 V/m			2000 – 2700 MHz		
		3 V/m	5100 – 6000 MHz						
3	antenna	10 V/m	50% duty cycle, 200 Hz rep. rate	n.a.	900 ± 5 MHz	yes	A		
Electrical fast transients/burst	IEC / EN 61000-4-4	3 ⁸	capacitive, o/c	$\pm 2000 V_p$	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	$\pm 4000 V_p$					
Surges	IEC / EN 61000-4-5	3 ⁹	i/c	$\pm 2000 V_p$	1.2/50 μs	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	A
			+i/-i	$\pm 1000 V_p$		2 Ω			
Conducted disturbances	IEC / EN 61000-4-6	3 ¹⁰	i, o, signal wires	10 VAC (140 dB μ V)	AM 80% 1 kHz	150 Ω	0.15 – 80 MHz	yes	A
Power frequency magnetic field	IEC / EN 61000-4-8	3 ¹¹	--	100 A/m			60 s in all 3 axis	yes	A
Pulsed magnetic field	IEC / EN 61000-4-9	-	--	$\pm 300 A/m$			5 pulses per axis repetit. rate 10 s	yes	B

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

⁵ Exceeds EN 50121-3-2:2015 table 6.3 and EN 50121-4:2006 table 1.4.

⁶ Corresponds to EN 50121-3-2:2015 table 6.1 and exceeds EN 50121-4:2006 table 1.1.

⁷ Corresponds to EN 50121-3-2:2015 table 6.2 and EN 50121-4:2006 table 1.2 (compliance with digital mobile phones).

⁸ Corresponds to EN 50121-3-2:2015 table 5.2 and EN 50121-4:2006 table 2.2.

⁹ Covers or exceeds EN 50121-3-2:2015 table 4.3 and EN 50121-4:2006 table 2.3.

¹⁰ Corresponds to EN 50121-3-2:2015 table 5.1 and EN 50121-4:2006 table 3.1 (radio frequency common mode).

¹¹ Corresponds to EN 50121-4:2006 table 1.3.

¹² Corresponds to EN 50121-4:2006 table 1.5.

Electromagnetic Emissions

All models comply with Class A according to EN 55011/55022 for conducted and radiated emissions.



Fig. 15a
Typ. conducted emissions (peak/quasipeak and average) at the input according to EN 55011/22, measured at $V_i = 230\text{ V}$ and $I_{o\text{ nom}}$ (LR2320-9G).

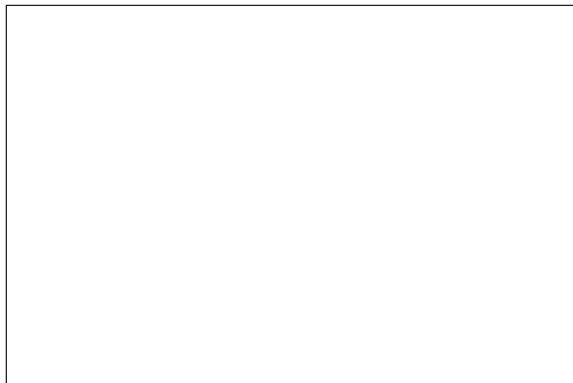


Fig. 15b
Typ. conducted emissions (peak/quasipeak and average) at the input according to EN 55011/22, measured at $V_i = 230\text{ V}$ and $I_{o\text{ nom}}$ (LR2320-9G).



Fig. 16a
Typ. radiated emissions accord. to EN 55011/22, antenna 10 m distance, measured at $V_i = 230\text{ V}$ and $I_{o\text{ nom}}$ (LR2880-9G).

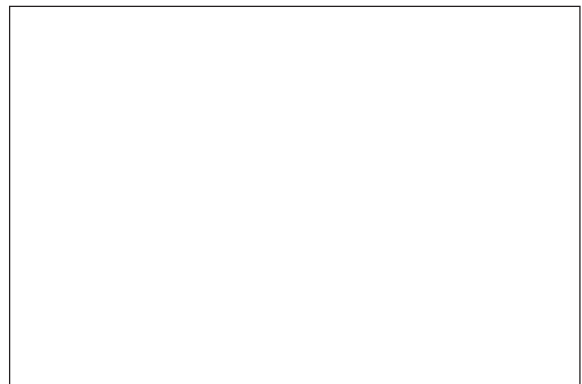


Fig. 16b
Typ. radiated emissions accord. to EN 55011/22, antenna 10 m distance, measured at $V_i = 230\text{ V}$ and $I_{o\text{ nom}}$ (LR2880-9G).

Immunity to Environmental Conditions

Table 8: Mechanical and climatic stress (type tests)

Test method		Standard	Test conditions		Status
Cab	Damp heat steady state	IEC/EN 60068-2-78 MIL-STD-810D section 507.2	Temperature: Relative humidity: Duration:	40 ±2 °C 93 +2/-3 % 56 days	Converter not operating
Db	Damp heat test, cyclic	EN 50155:2007, clause 12.2.5 IEC/EN 60068-2-30	Temperature: Cycles (respiration effect): Duration:	55 °C and 25 °C 2 2 × 24 h	Converter not operating
Bd	Dry heat test steady state	EN 50155:2007, clause 12.2.4 IEC/EN 60068-2-2	Temperature: Duration:	70 °C 6 h	Converter operating
Ad	Cooling test steady state	EN 50155:2007, clause 12.2.3 IEC/EN 60068-2-1	Temperature, duration Performance test	-40 °C, 2 h +25 °C	Conv. not operating
--	Salt mist test sodium chloride (NaCl) solution	EN 50155:2007, clause 12.2.10 class ST3	Temperature: Duration:	35 ±2 °C 48 h	Converter not operating
Fc	Vibration (sinusoidal)	IEC/EN 60068-2-6 MIL-STD-810D section 514.3	Acceleration amplitude: Frequency (1 Oct/min): Test duration:	0.35 mm (10 – 60 Hz) 5 g _n = 49 m/s ² (60 - 2000 Hz) 10 – 2000 Hz 7.5 h (2.5 h in each axis)	Converter operating
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 8 – 500 Hz 4.9 g _{n rms} 1.5 h (0.5 h in each axis)	Converter operating
E b	Bump (half-sinusoidal)	IEC/EN 60068-2-29 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	25 g _n = 245 m/s ² 6 ms 6000 (1000 in each direction)	Converter operating
E a	Shock (half-sinusoidal)	IEC/EN 60068-2-27 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	50 g _n = 490 m/s ² 11 ms 18 (3 in each direction)	Converter operating
--	Shock	EN 50155:2007 clause 12.2.11, EN 61373 sect. 10, class B, body mounted ¹	Acceleration amplitude: Bump duration: Number of bumps:	5.1 g _n 30 ms 18 (3 in each direction)	Converter operating
--	Simulated long life testing at increased random vibration levels	EN 50155:2007 clause 12.2.11, EN 61373 sect. 8 and 9, class B, body mounted ¹	Acceleration spectral density: Frequency band: Acceleration magnitude: Test duration:	0.02 g _n ² / Hz 5 – 150 Hz 0.8 g _{n rms} 15 h (5 h in each axis)	Converter operating

¹ Body mounted = chassis of a railway coach

Temperatures

Table 8: Temperature specifications, valid for an air pressure of 800 - 1200 hPa (800 - 1200 mbar)

Temperature		-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	Non operational	-55	85	

¹ See *Thermal Considerations*.

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

Reliability

Table 9: MTBF and device hours

Ratings at specified case temperature between failures ¹	Model	MTBF	Demonstrated hours
Accord. to IEC 62380	LR2320-9RG		

¹ Statistical values, based upon an average of 4300 working hours per year and in general field use over 5 years; upgrades and customer-induced errors are excluded.

Mechanical Data

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

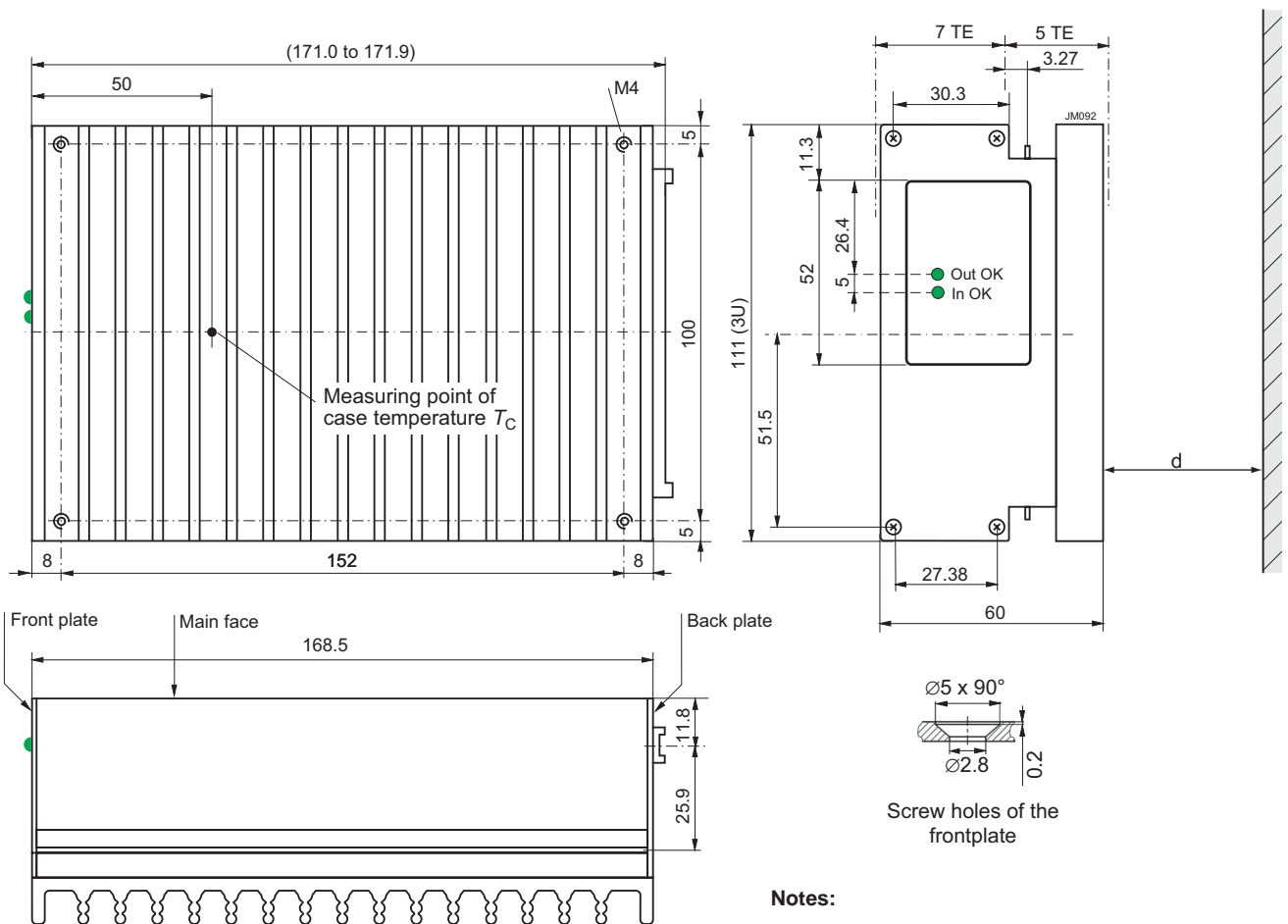


Fig. 17
 Aluminum case of LR models with heat sink;
 black finish (EP powder coated);
 weight approx. 1.5 kg

Notes:

- $d \geq 15$ 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.

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

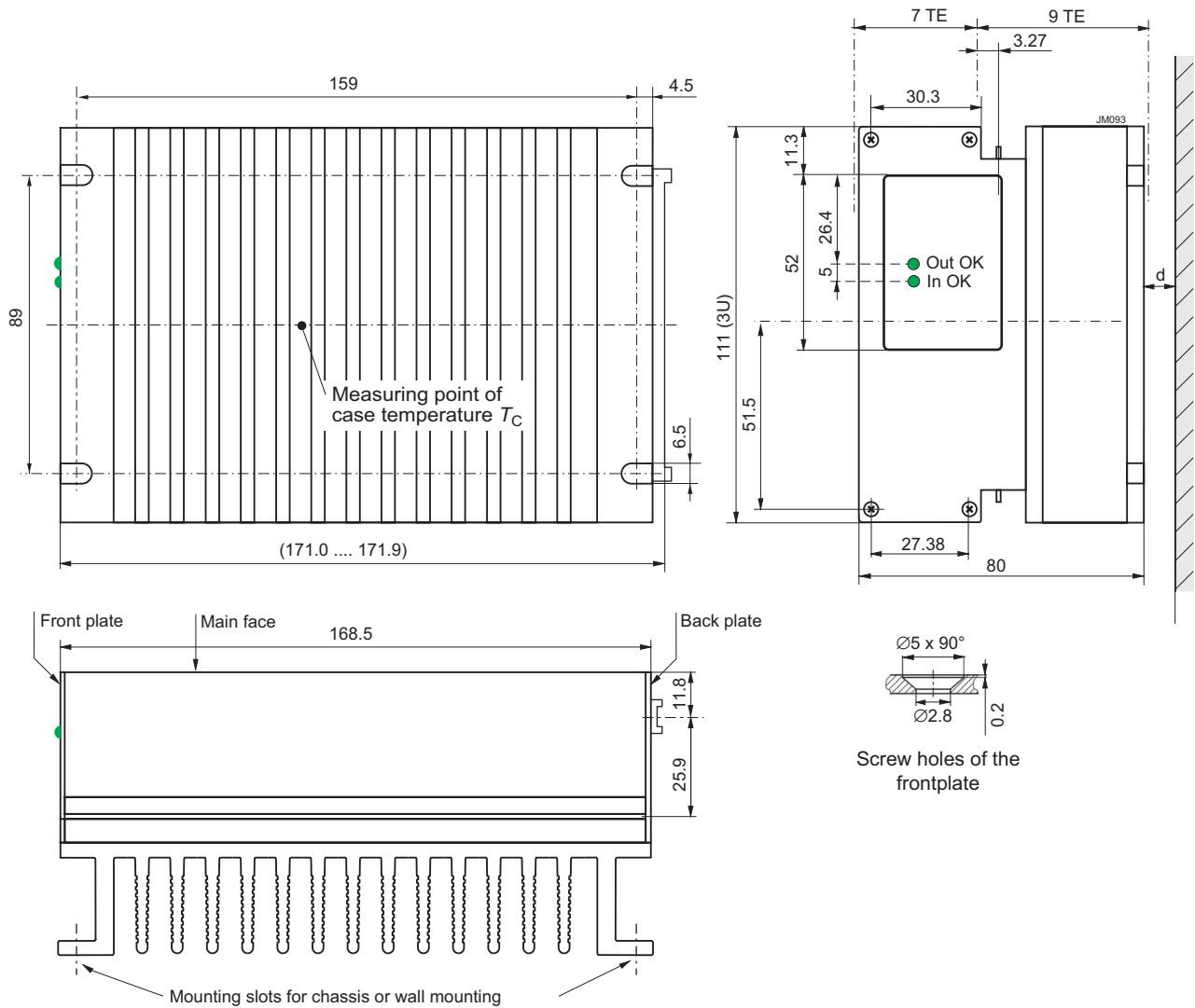


Fig. 18
Aluminum case of LRP models with heat sink;
black finish (EP powder coated);
weight approx. 1.8 kg

Notes:

- $d \geq 15$ 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.

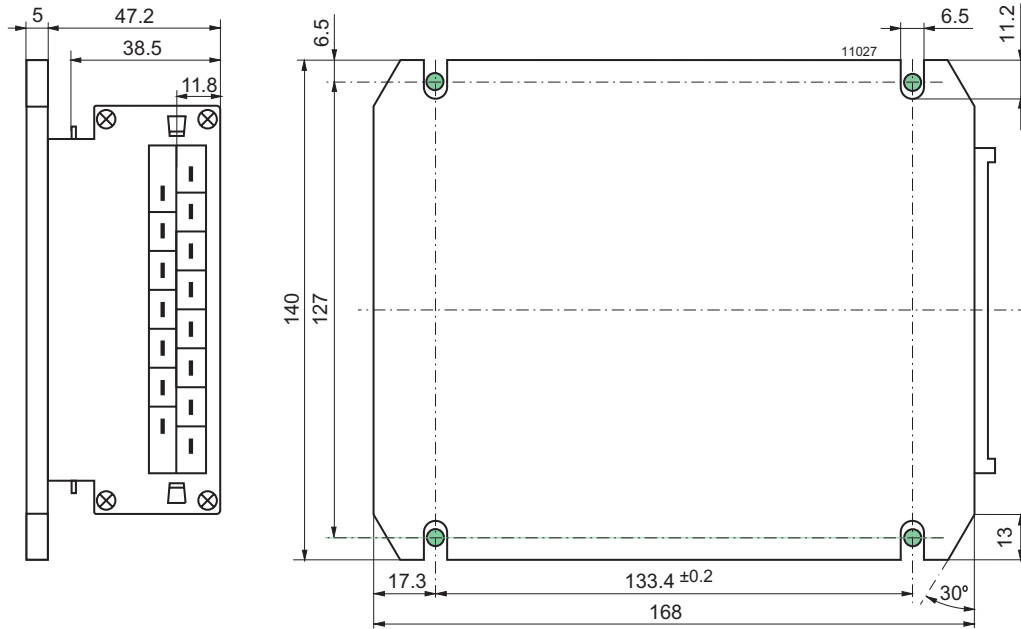


Fig. 19
Option B: Aluminum case S with large cooling plate; black finish (EP powder coated).
Suitable for front mounting.
Total weight approx. 1.5 kg



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

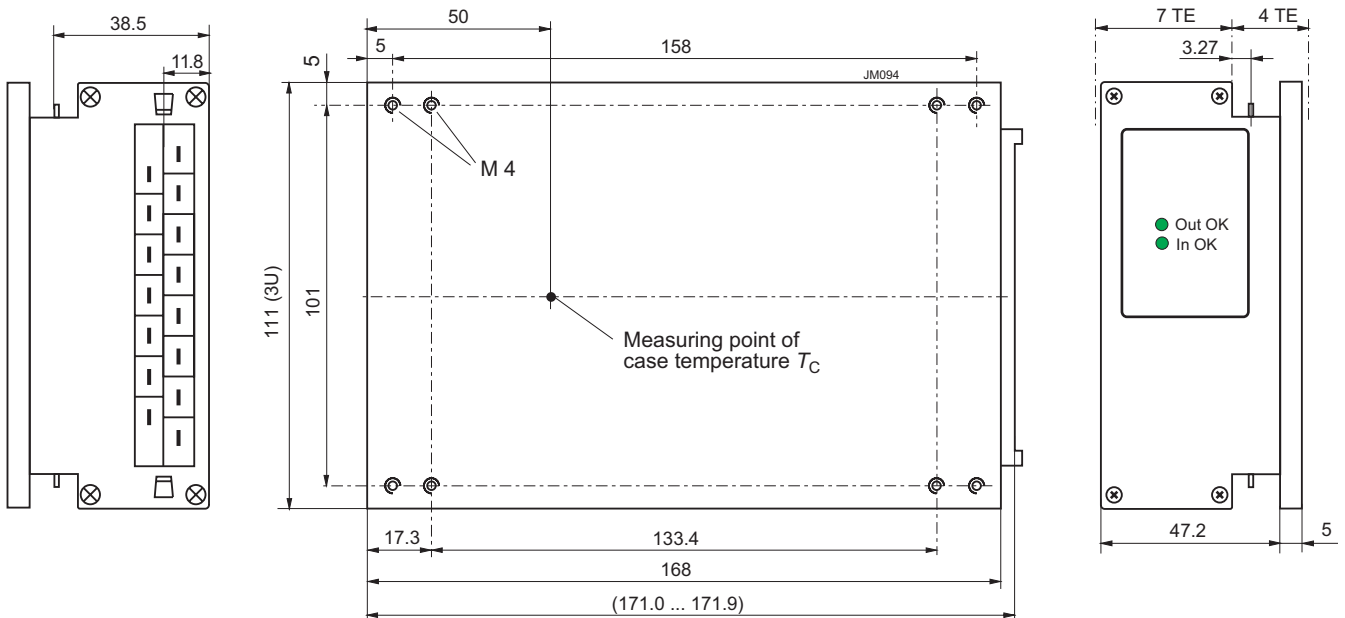


Fig. 20
Option B1: Aluminum case S with small cooling plate; black finish (EP powder coated).
Suitable for mounting with access from the backside.
Total weight approx. 1.4 kg.

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.

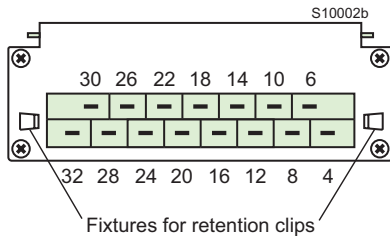


Fig. 21
View of module's male connector

Table 10: Pin allocation

Pin no.	Name	Function
4	Vo1+	Pos. output 2
6	Vo1+	Pos. output 2
8	Vo1-	Neg. output 2
10	Vo1-	Neg. output 2
12	Vo2+	Pos. output 1
14	Vo2-	Neg. output 1
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 14 (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 60950-1 2nd Ed. and IEC/EN 60950-1 2nd Ed.

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 fulfill the requirements of a fire enclosure.

The output voltage is considered as SELV, except LR/LRP2880 with series-connected outputs.

The converters are subject to manufacturing surveillance in accordance with the above mentioned standards and ISO 9001:2008. CB-scheme is available on request.

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 NF-F16 (I2/F1). They also comply with EN 45545-1, EN 45545-2 (2013), 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 50514 and IEC/EN 60950 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 case to the earth pin (<0.1 Ω) is tested as well.

Table 11: Isolation

Characteristic		Input to case and outputs	Outputs to case and input	Output 1 to output 2	Alarm signals to everything	Unit
Electric strength test	Factory test 1 to 4 s	2.84 ¹	4.3	0.5	4.3	kVDC
	AC test voltage equivalent to factory test	2.0 ¹	3.0	0.3	3.0	kVAC
Insulation resistance at 500 VDC		>300	>300	>300	--	MΩ
Creepage distances		≥3.2 ²	≥4.5	--	--	mm

¹ According to EN 50116 and IEC/EN 60950, subassemblies connecting input to output are pre-tested with 5.6 kVDC or 4 kVAC.

² Input to outputs: 6.4 mm

Description of Options

F0, F2 Fuse Options

The converters exhibit 1 fuse in the phase line.

Option F0 is required for full compliance with EN 50155 (no fuse allowed).

Option F2 is required for 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).

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*):

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

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

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. 25.
- Mating H15 connectors with screw, solder, faston, or press-fit terminals.
- Coding clips for connector coding HZZ00202
- Pair of connector retention clips HZZ01209-G
- 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. 28.
- 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. 32, 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:

www.belpowersolutions.com/power



Fig. 22
Different front panels

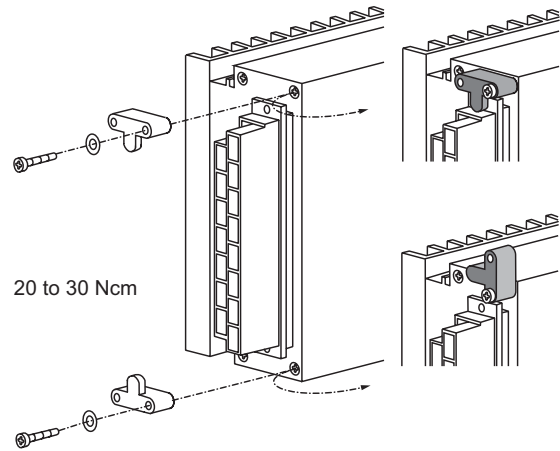


Fig. 23
Connector retention brackets HZZ01216-G (CRB-HKMS)

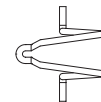


Fig. 24
Connector retention clips to fasten the H15 connector to the rear plate; see fig. 24. HZZ01209-G consists of 2 clips.

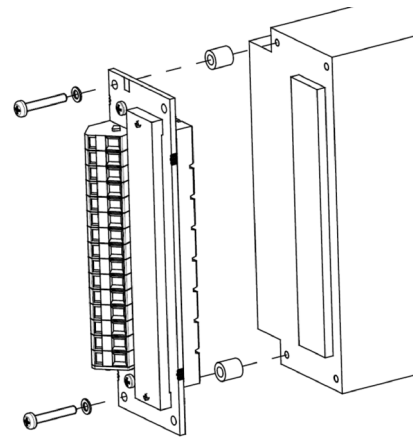


Fig. 25
Cage clamp adapter HZZ00144-G



Fig 29
Different cable hoods

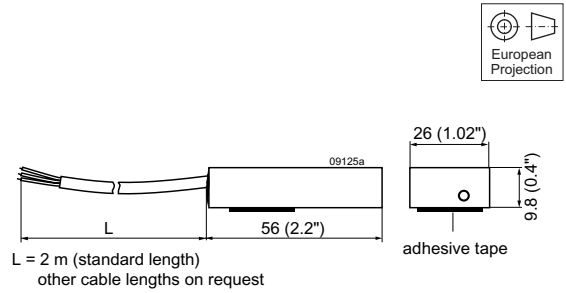


Fig. 32
Battery temperature sensor



Fig. 30
Chassis- or wall-mounting plate
HZZ01213-G (Mounting plate K02)

Table 12: 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.

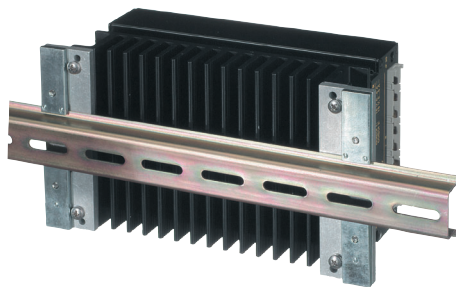


Fig. 31
DIN-rail mounting assembly HZZ00615-G (DMB-K/S)

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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