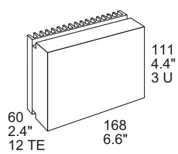
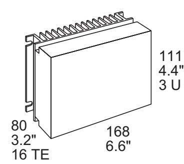
power-one® Changing the Shape of Power





RoHS Compliant

Features

- Extremely wide input voltage range from 12 to 168 VDC in the same model
- RoHS compliant
- Class I equipment
- Input over- and programmable undervoltage lockout
- Shutdown function
- Inrush current limitation
- 10 ms hold-up time
- Adjustable output voltages
- 2 independent, isolated outputs: no load, overload, and short-circuit proof
- Rectangular current limiting characteristic
- Parallel operation with active current sharing
- Very high efficiency up to 94%
- Immunity according to IEC 61000-4-2, -3, -4, -5, -6
- ALL PCBs protected by lacquer
- Very high reliability

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

C US

Description

The HR Series of DC-DC converters represents versatile power supplies ideally suitable for use in transportation and other advanced electronic systems. Features include a very broad input voltage range, very high efficiency, high reliability, low output voltage noise, and excellent dynamic response to load/line changes. They can be connected to all conventional railway batteries.

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. To avoid high input current at operation with high-voltage batteries, the inhibit input allows for adjusting of the undervoltage lockout to a suitable level, thus allowing the use of an appropriate input fuse.

The converters exhibit an inrush current limiter, preventing 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. The converters are particulary suitable for railway applications and can be supplied by all common railway batteries of 24 V, 36 V, 48 V, 72 V, 96 V,110 V, and 120 V nominal voltage. The converters comply with EN 50155 and EN 50121-3-2. All boards are coated with a protective lacquer.

The case design allows 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 may 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.

Table of Contents

Changing the Shape of Power

Model Selection

Table 1: Model Selection

Output 1		Output 2		Input voltage			η at 24 V[1]		η at 110 V[2]		Model	Opt.
$V_{o\,nom}$ [V]	$I_{o\,nom}$ [A]	$V_{o\,nom}$ [V]	$I_{o\,nom}$ [A]	$V_{i\,min}$[3] [V]	$V_{i\,cont}$ [V]	$V_{i\,max}$[3] [V]	min. [%]	typ. [%]	min. [%]	typ. [%]		
12 12	10 12	12 12	10 12	12 12	16.8 to 150 16.8 to 150	168 168	90	92.5	92	94.5	HR2320-9RG HRP2320-9RG	B, B1 B, B1
12 12	20 24	-- --	-- --	12 12	16.8 to 150 16.8 to 150	168 168	90	92.5	92	94.5	HR2320-9RG[4] HRP2320-9RG[4]	B, B1 B, B1
24 24	10 12	-- --	-- --	12 12	16.8 to 150 16.8 to 150	168 168	90	92.5	92	94.5	HR2320-9RG[5] HRP2320-9RG[5]	B, B1 B, B1

1 Efficiency at T_A = 25 °C, $V_{i\,nom}$ = 24 V, $I_{o\,nom}$
2 Efficiency at T_A = 25 °C, $V_{i\,nom}$ = 110 V, $I_{o\,nom}$
3 Short time; see table 2 for details
4 Both outputs connected in parallel
5 Both outputs connected in series

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 to the interleaved switching boost converter, which provides the intermediate circuit voltage on 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 is charged.

The bulk capacitor sources a single-transistor forward converter with active clamp and provides the power during the interruption time of 10 ms.

The main transformer exhibits two separate 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 power choke and output filters. The control logic senses the main output voltage V_{o1} and generates the control signal for the forward converter, with respect to the max. output current transferred via magnetic feedback to the control circuit of the forward converter, located on the primary side.

The second output voltage is tracking the main output, but has its own current limiting circuit. If the main output voltage drops due to current limitation, the second output voltage will fall as well and vice versa.

The output voltages can be adjusted by external means. Parallel operation of several converters is possible. A logic circuit ensures reasonable current sharing. Both outputs can be connected in parallel or in series without any precaution. They exhibit a rectangular current limitation characteristic.

A control output (D) and two LEDs signal correct operation of the converter.

Input over- and undervoltage lockout is provided. The undervoltage trigger level can be adjusted by an external resistor according to the nominal voltage of the supply battery.

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

A cooling plate for chassis-mounting is available as option.

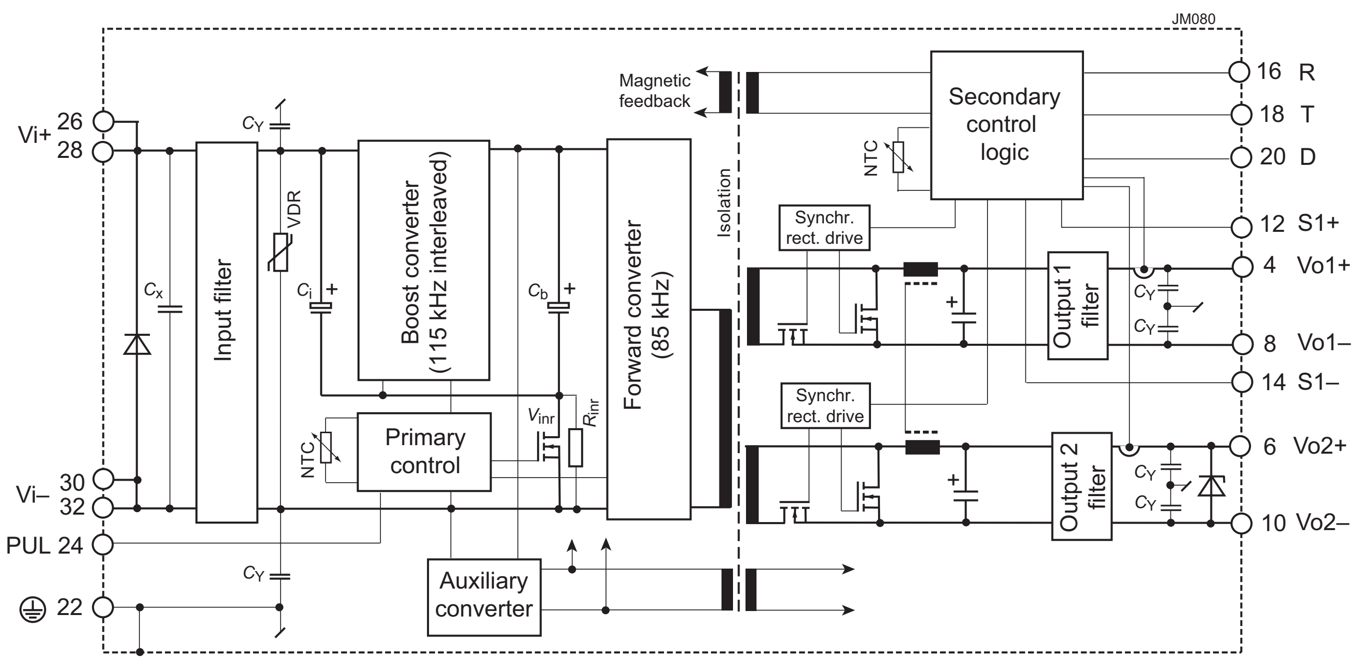


Fig. 1
Block diagram

power-one® Changing the Shape of Power

Electrical Input Data

General Conditions:

- T_A = 25 °C, unless T_C is specified.
- Pin 24 (PUL) ≥ 5 V, unless otherwise specified
- Pin 16 (R) and 18 (D) left open-circuit.

Table 2: Input data

Model			HR2320			HRP2320			Unit
Characteristics		**Conditions**	**min**	**typ**	**max**	**min**	**typ**	**max**	
V_i	Operating input voltage	$I_o = 0 - I_{o\,max}$ $T_{C\,min} - T_{C\,max}$	16.8		150	16.8		150	V
	for ≤2 s				168			168	
	for ≤2 s	without shutdown	12.0			12.0			
$V_{i\,nom}$	Nominal input voltage range		24	(110)	120	24	(110)	120	
$V_{i\,abs}$	Input voltage limits	3 s, without damage	0		176	0		176	
I_i	Typical input current	$V_{i\,max}$ .. (110 V) .. $V_{i\,min}$, $I_{o\,nom}$	1.76	(2.36)	15.65	2.1	(2.83)	21.4	A
$P_{i\,0}$	No-load input power	$V_{i\,min} - V_{i\,max}$, $I_o = 0$			4.0			4.0	W
$P_{i\,inh}$	Idle input power	$V_{i\,min} - V_{i\,max}$, PUL = 0 V			2.5			2.5	
C_x	Input capacitance [1]			8.6			8.6		µF
$I_{inr\,p}$	Peak inrush current [2]	V_i = 150 V, $I_{o\,nom}$		30			30		A
$t_{inr\,r}$	Time constant of I_{inr}			10			10		ms
$t_{d\,on}$	Start-up time	0 → $V_{i\,min}$, $I_{o\,nom}$			400			400	
t_r	Rise time after shutdown	V_i ≥16.8 V, $I_{o\,nom}$, PUL 0→ 5 V			40			40	
R_i	Input resistance			10					mΩ

[1] At start-up (not smoothed by the inrush current limiter)
[2] According to ETS 300132-2

Input Protection and Fuse

This converter is designed for an extremly wide input voltage range, allowing for connection to all common railway batteries. However, the programmable input undervoltage lockout (PUL, pin 24) should be adjusted adequately in order to limit the high input current at start-up; see fig 2. Table 3 shows the values of the resistor R_{PUL}, connected between PUL and Vi–, versus the resultant minimum input voltage and the resultant maximum input current.

Fig. 3 shows more values of R_{PUL} versus start-up voltage. For stationary batteries, a higher start-up voltage might be advatageous.

Note: If PUL (pin 24) is connected to Vi– (pin 30/32), the converter is disabled (shutdown).

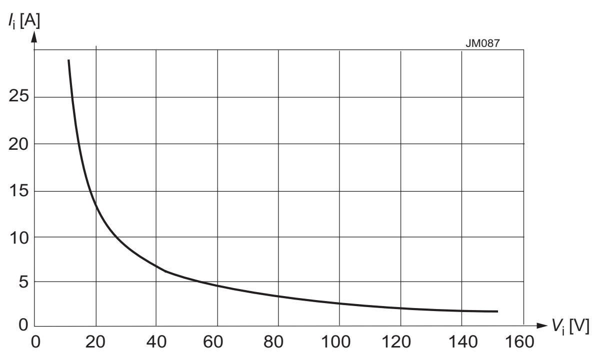


Fig. 2
Typical input current at nominal load versus input voltage

Table 3: Specification of PUL (typ.) and recommended external fuse for railway application

Battery	R_{PUL}	$V_{i\,min}$ (on / off)		Fuse rating
24 V	∞	15	12 V	25 A, fast, Littlefuse 314 [1]
36 V	16.9 kΩ	20	17	16 A, fast, Schurter /SP [2]
48 V	14 kΩ	26	20	12.5 A, fast, Schurter /SP [2]
72 V	10 kΩ	38	32	8 A, fast, Schurter /SP [2]
110 V	5.6 kΩ	62	56	6.3 A, slow, BEL fuse MRT [2]
120 V	2.8 kΩ	90	84	5 A, slow, BEL fuse MRT [2]
all	0 Ω	Converter disabled		

[1] Fuse size 6.3 × 32 mm [2] Fuse size 5 × 20 mm

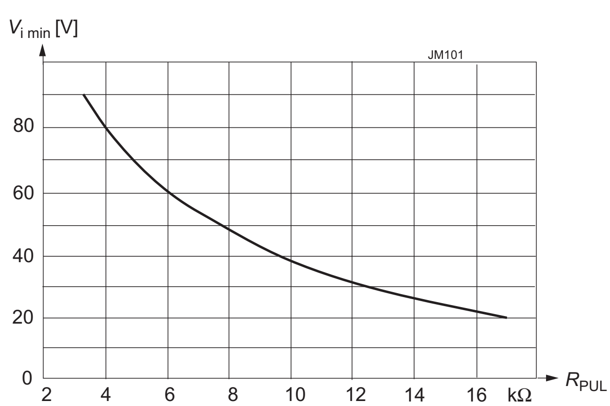


Fig. 3
R_{PUL} versus switch-on voltage

No fuse is incorporated inside the converter. Consequently, an external fuse or a circuit breaker at system level must be installed to protect against severe defects.

Reverse polarity protection is provided by an antiparallel diode across the input, causing the external input fuse or circuit breaker to trip.

Input Transient Protection

The input fuse together with a VDR (voltage depending resistor) and a double stage symmetrical input filter form an effective protection against high input transient voltages which typically occur in battery-driven mobile applications.

At very high input voltage, the overvoltage lockout disables the converter such protecting it from damage.

Inrush Current Limitation

The converters exhibit an electronic inrush current limiting circuit. This circuit is also functional, when the input voltage is removed and immediately reapplied.

However, several capacitors are directly connected to the input pins. Consequently, a peak curent is still present when applying the input voltage.

The inrush current peak value can be determined by following calculation; see also fig. 4:

$$I_{inr\,p} = \frac{V_{i\,source}}{(R_{s\,ext} + R_i)}$$

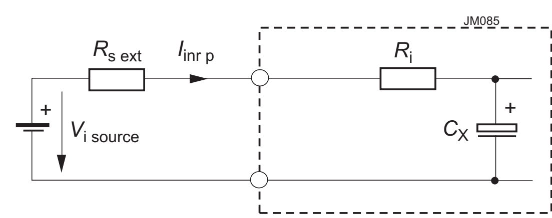


Fig. 4
Equivalent input ciruit

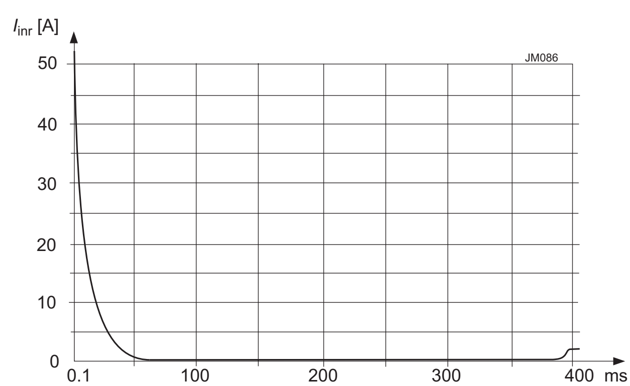


Fig. 5
Inrush current at $V_i = 150$ V, $I_{o\,nom}$

Electrical Output Data

General Conditions:

- T_A = 25 °C, unless T_C is specified.
- Pin 24 (PUL) ≥ 5 V

Table 6: Output data of double-output models.

Model	**Nom. output voltage**			**HR2320 2 × 12 V**						**HRP2320 2 × 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 $I_{o\,nom}$	11.88	12.0	12.12		12.0		11.88	12.0	12.12		12.0		V
$V_{o\,BR}$	Output protection (suppressor diode)		Output 2		--		14.4		15.9		--		14.4		15.9	
$I_{o\,nom}$	Output current nom.		$V_{i\,min}$ – $V_{i\,max}$ $T_{C\,min}$ – $T_{C\,max}$		10			10			12			12		A
I_{o1L}, I_{o2L}	Output current limit[1]			10.5			10.5			12.3			12.3			
I_{o12L}	Output current limit[1 2]			21[2]			--			24.6[2]		--				
v_o	Output noise	---	$V_{i\,nom}$, $I_{o\,nom}$ BW = 20 MHz		-			-			-			-		mV$_{pp}$
		Switching freq.			-			-			-			-		
		Total incl.spikes				60			60			60			60	
$V_{o\,adj}$	Adjustment by R-input[4]		$V_{i\,min}$ – $V_{i\,max}$ (0.1 – 1) $I_{o\,nom}$	7.5		13.8		[3]		7.5		13.8		[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 regulat.	Voltage deviation[5]	$V_{i\,nom}$, $I_{o1\,nom}$ ↔ 0.5 $I_{o1\,nom}$ 0.5 $I_{o2\,nom}$		±200			±200			±250			±250		
t_d		Recovery time[5]			1			[3]			1			[3]		ms
α_{vo}	Temperature coefficient of output voltage		$T_{C\,min}$ – $T_{C\,max}$ $I_{o\,nom}$		+0.01	+0.02		--			+0.01	+0.02		--		%/K

1 If the output voltages are increased above $V_{o\,nom}$ through R-input control, remote sensing, 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*

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 and 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) allow for T_A to be 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.

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 (Hold-Up)

The integrated storage capacitor (C_b) is loaded to the boost voltage and ensures full output voltage with nominal load during an interruption time (or ride-through time) of at least 10 ms, provided that V_i was ≥ 20 V before the interruption. This complies to EN 50155 class S2.

Efficiency

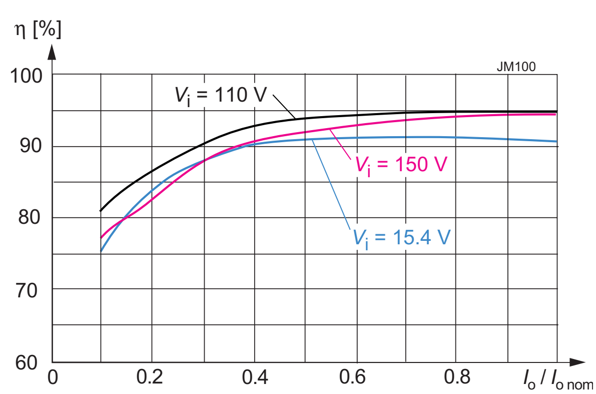


Fig. 6
Efficiency versus V_i *and* I_o *(both outputs series-connected)*

Output Protection

The 2nd output is protected by suppressor diode against overvoltage, which could occur due to a failure of the internal control circuit. This suppressor diode was not designed to withstand an externally applied overvoltage. Overload at any of the outputs will cause a shut-down of both outputs.

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

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

Parallel and Series Connection

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

Outputs of different converters can be series-connected, but the output voltage may exceed the SELV level.

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 providing 24 V, Vo1– of both converters should be connected together and the T-pins as well. See fig. 8.

Notes:

- Not more than 5 converters should be connected in parallel.
- The R pins should be left open-circuit. If not, the output voltages must be individually adjusted prior to paralleling within 1 to 2% or the R pins should be connected together.
- Series connection of second outputs without involving their main outputs should be avoided, as regulation may be poor.

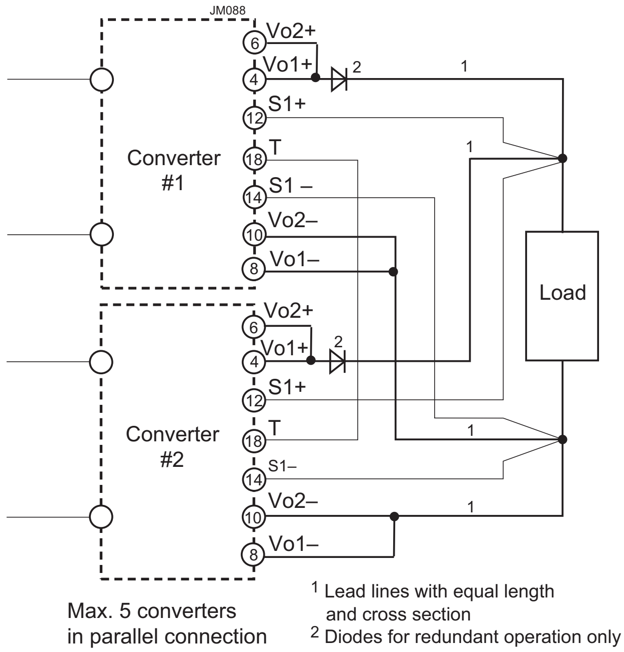


Fig. 7
Parallel connection with ORing diodes and sense lines connected at the load

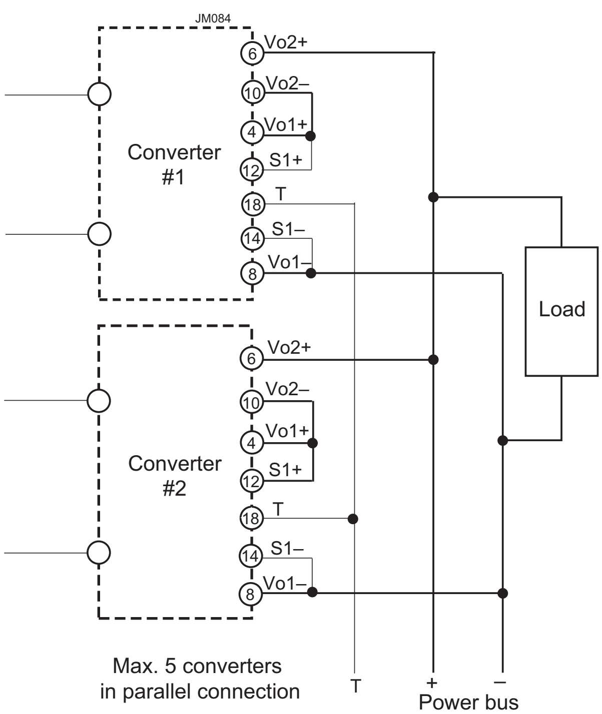


Fig. 8
Parallel connection of double-output models with the outputs of each converter connected in series, using option T.
The signal at the T pins is referenced to Vo1–.

Output Voltage Regulation

If both outputs are connected in parallel or in series, the converter exhibits a rectangular output characterisitic; see fig. 9.

The typ. dynamic load regulation illustrates fig. 10.

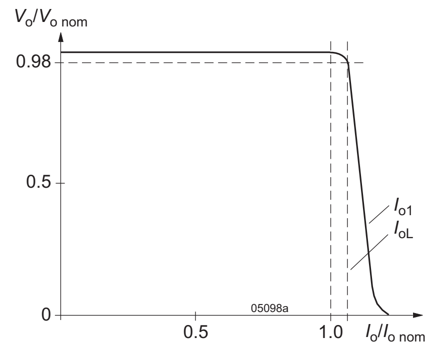


Fig. 9
Output characteristic V_o versus I_o (both outputs connected in parallel or in series)

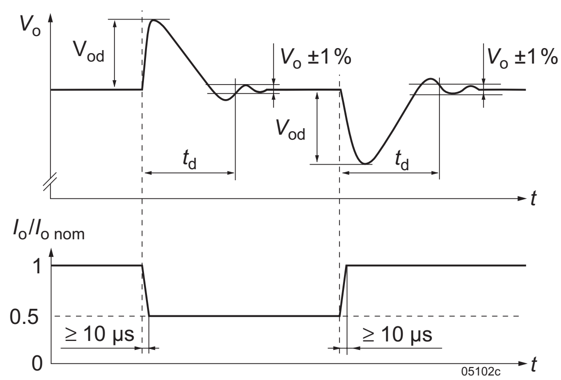


Fig. 10
Typical dynamic load regulation of V_o.

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

V_{o2} depends upon the load distribution; see fig. 11.

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

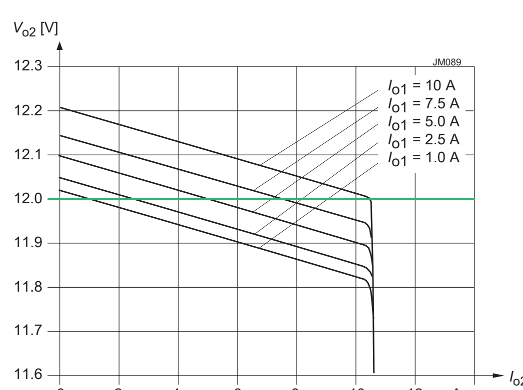


Fig. 11
Models HR2320 (2 outputs 12 V): V_{o2} versus I_{o2} with various I_{o1}

Auxiliary Functions

Shutdown

The PUL input (pin 24) can be used as shutdown; see table 3. The responsetime t_r is specified in table 2.

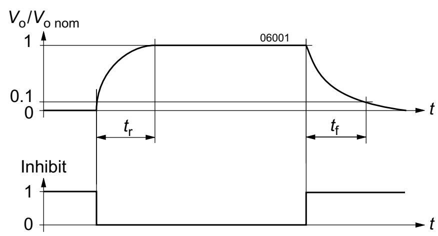


Fig. 11
Typical output response to the PUL (inhibit) signal

Current Share Function

If the pins 18 (T) of parallel-connected converters are linked together, the converters share the output current evenly. Refer to section *Parallel and Series Connection*.

Output Undervoltage Monitor

The output undervoltage monitor generates a logic "low" signal (NPN open-collector output) at the D-output (pin 20), when the output voltage $V_{o\,nom}$ is in range. Then, a green LED (Out OK) at the frontplate is illuminated.

At low D-output, the current is limited by a 10 Ω protective resistor. If the output is open, the voltage must remain below 50 V.

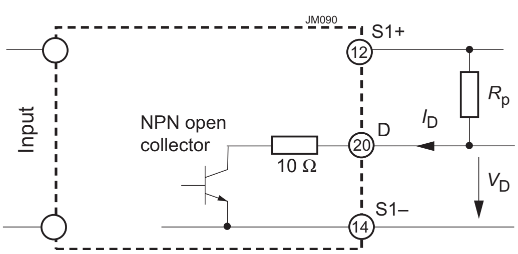


Fig. 12
Output voltage monitor

Sense Lines

This feature allows for compensation of voltage drops across the connector contacts and if necessary, across the load lines. We recommend connecting the sense lines directly at the female connector.

To ensure correct operation, both sense lines (S1+, S1–) should be connected to their respective power outputs (Vo1+ and Vo1–), and the voltage difference between any sense line and its respective power output (as measured on the connector) should not exceed the following values:

Table 7: Maximum voltage compensation allowed using sense lines

Output voltage	Total voltage difference between sense lines and their respective outputs	Voltage difference between Vo1– and S1–
12 V	<1.0 V	<0.25 V

Important: Sense lines must always be connected! Incorrectly connected sense lines may activate the overvoltage protection resulting in a permanent short-circuit of the output.

Programmable Output Voltage

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 $V_{o\,nom}$.

a) Adjustment by means of an **external control voltage V_{ext}** between pin 16 (R) and pin 14 (S1–):

The control voltage range is 1.55 – 2.875 V and allows for an adjustment in the range of approximately 0.75 – 115% of $V_{o\,nom}$.

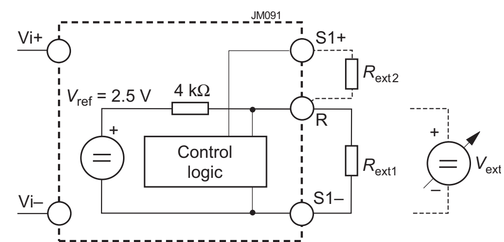


Fig. 13
Output voltage adjustment

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

Caution: Applying an external control voltage >2.875 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 14 (S1–) to achieve an output voltage adjustment range of approximately 0.75 – 100% of $V_{o\,nom}$.

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

or: between pin 16 (R) and pin 8 (Vo1+) to achieve an output voltage adjustment range of 100 – 115% of $V_{o\,nom}$.

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

Caution: The value of R'_{ext} shall never be less than the value for increasing V_{o1} to 115% to prevent the converter from damage!

Notes:

– If the output voltages are increased above $V_{o\,nom}$ via R-input control, sense lines, 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.

Led Indicators

Two green LEDs are visible at the front plate:

- Out OK; see *Output Voltage Monitor* and fig. 12
- In OK. This LED is activated when V_i is greater than $V_{i\,min}$, whereas $V_{i\,min}$ is defined by the adjust resistor on the PUL input (pin 24).

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 accoring to the battery temperature.

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

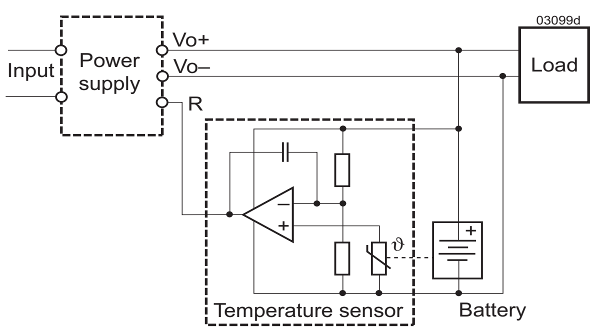


Fig. 14
Connection of a temperature sensor

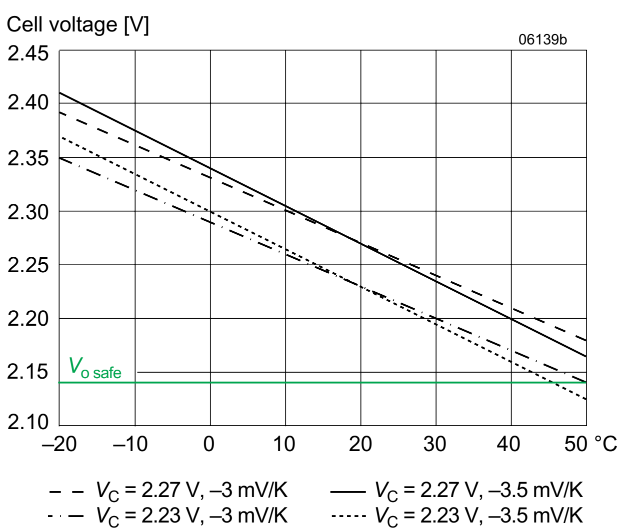


Fig. 15
Trickle charge voltage versus temperature for defined temperature coefficient. $V_{o\,nom}$ is the output voltage with open R-input.

Electromagnetic Compatibility (EMC)

A metal oxide VDR together and an efficient input filter form an effective protection against high input transient voltages, which typically occur in most installations. The converters have been successfully tested to the following specifications:

Electromagnetic Immunity

Table 8: Electromagnetic immunity (type tests)

Phenomenon	Standard	Level	Coupling mode[1]	Value applied	Waveform	Source imped.	Test procedure	In oper.	Perf. crit.[2]
Electrostatic discharge (to case)	IEC/EN 61000-4-2	4 [5]	contact discharge	8000 V_p	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	A
			air discharge	15000 V_p					
Electromagnetic field	IEC/EN 61000-4-3	x [6]	antenna	20 V/m	AM 80% /1 kHz	n.a.	80 – 1000 MHz	yes	A
		[7]	antenna	20 V/m	AM 80% /1 kHz	n.a.	800 – 1000 MHz	yes	A
				10 V/m			1400 – 2100 MHz		
				5 V/m			2100 – 2500 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	±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 [9]	i/c	±2000 V_p	1.2/50 µs	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	A
			+i/–i	±2000 V_p		2 Ω			
Conducted disturbances	IEC/EN 61000-4-6	3 [10]	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 [11]	--	100 A/m			60 s in all 3 axis	yes	A

1 i = input, o = output, c = case
2 A = normal operation, no deviation from specs.; B = normal operation, temporary loss of function or deviation from specs possible
5 Exceeds EN 50121-3-2:2006 table 9.3 and EN 50121-4:2006 table 1.4.
6 Corresponds to EN 50121-3-2:2006 table 9.1 and exceeds EN 50121-4:2006 table 1.1.
7 Corresponds to EN 50121-3-2:2006 table 9.2 and EN 50121-4:2006 table 1.2 (compliance with digital mobile phones).
8 Corresponds to EN 50121-3-2:2006 table 7.2 and EN 50121-4:2006 table 2.2.
9 Covers or exceeds EN 50121-3-2:2006 table 7.3 and EN 50121-4:2006 table 2.3.
10 Corresponds to EN 50121-3-2:2006 table 7.1 and EN 50121-4:2006 table 3.1 (radio frequency common mode).
11 Corresponds to EN 50121-4:2006 table 1.3.

Electromagnetic Emissions

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

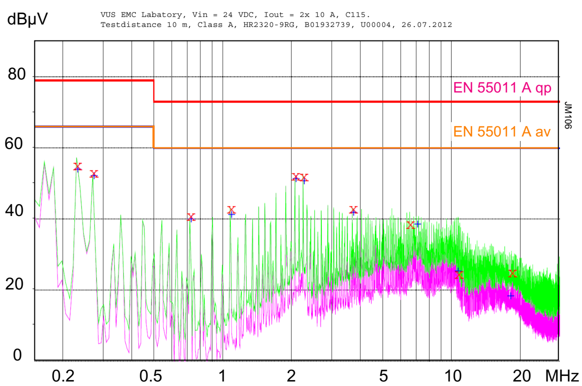


Fig. 16a
Typ. conducted emissions (peak/quasipeak and average) at the input according to EN 55011/22, measured at V_i = 24 V and $I_{o\,nom}$ (HR2320-9RG).

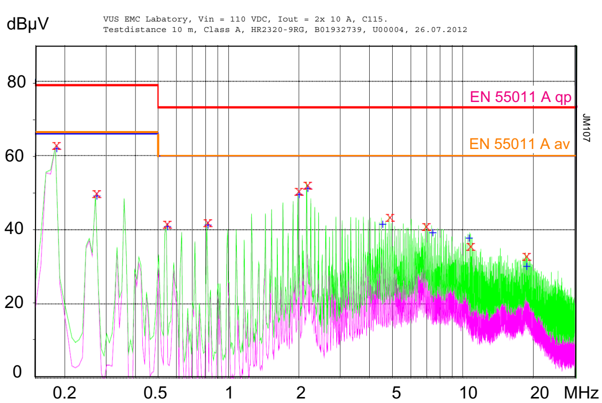


Fig. 16b
Typ. conducted emissions (peak/quasipeak and average) at the input according to EN 55011/22, measured at V_i = 110 V and $I_{o\,nom}$ (HR2320-9RG).

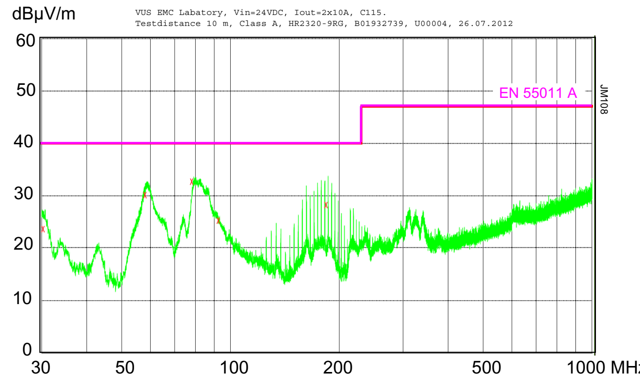


Fig. 17a
Typ. radiated emissions accord. to EN 55011/22, antenna 10 m distance, measured at V_i = 24 V and $I_{o\,nom}$ (HR2320-9RG).

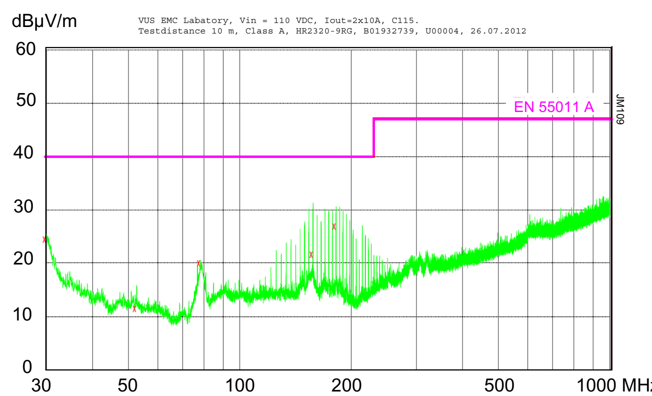


Fig. 17b
Typ. radiated emissions accord. to EN 55011/22, antenna 10 m distance, measured at V_i = 110 V and $I_{o\,nom}$ (HR2320-9RG).

power-one® Changing the Shape of Power

Immunity to Environmental Conditions

Table 9: 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: Relative humidity: Duration:	$40^{\pm 2}$ °C $93^{+2/-3}$ % 56 days	Converter not operating
Kb	Salt mist, cyclic (sodium chloride NaCl solution)	IEC/EN 60068-2-52	Concentration: Storage: Duration:	5% (30 °C) for 2 h 40°C, 93% rel. humidity for 3 cycles of 22 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/s² (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
Eb	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/s² 6 ms 6000 (1000 in each direction)	Converter operating
Ea	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/s² 11 ms 18 (3 in each direction)	Converter operating
--	Shock	EN 50155:2007 sect. 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 sect. 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 10: 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		100	

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

Reliability

Table 11: MTBF and device hours

Ratings at specified Case Temperature	Models	Ground benign 40 °C	Ground fixed 40 °C	Ground fixed 70 °C	Ground mobile 50 °C	Naval, sheltered 40 °C	Device hours [1]	Unit
MTBF	HR2320							h

[1] Statistical values, based on 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.

European Projection

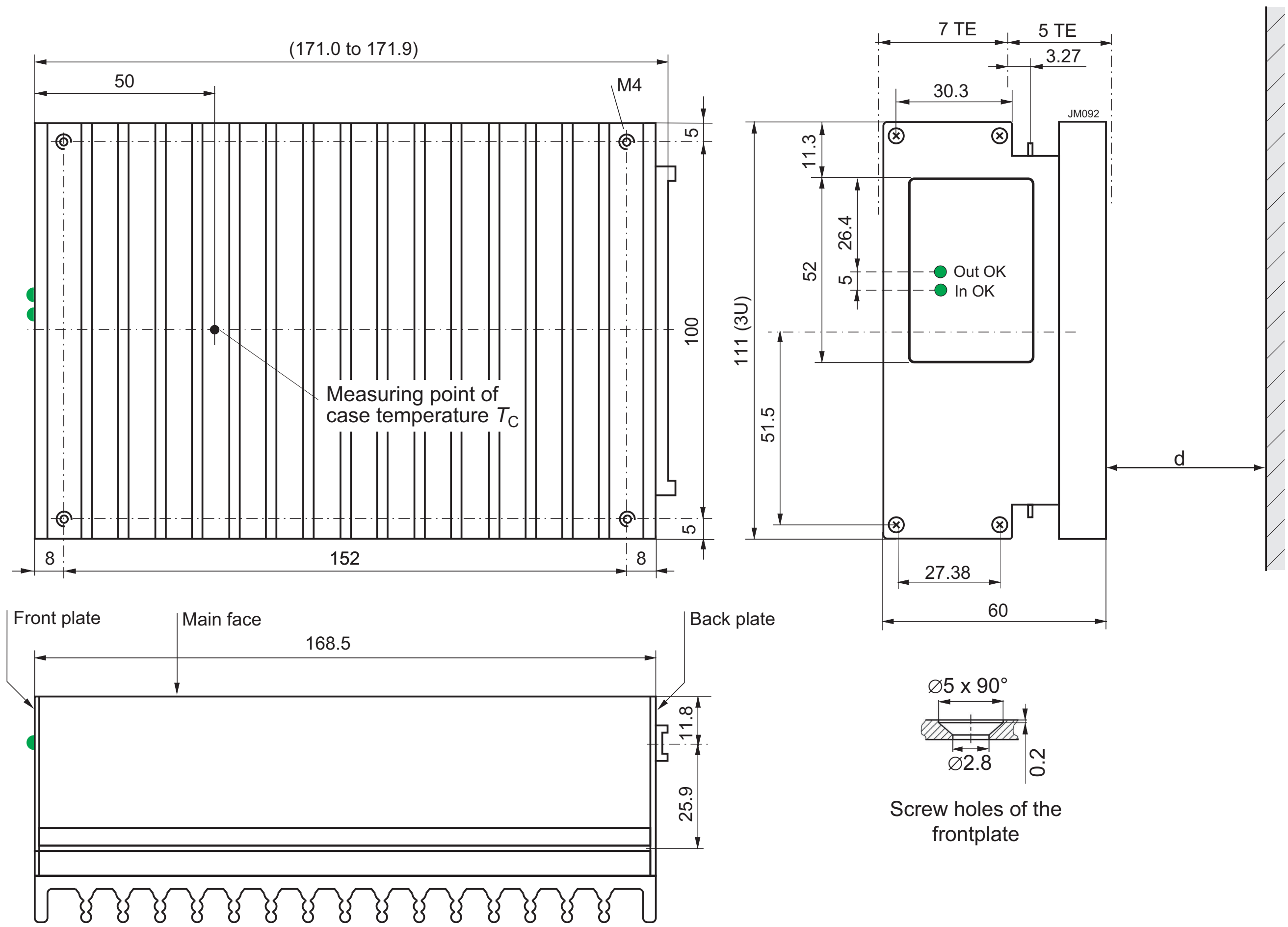


Fig. 18
Aluminium case of HR2320 with heat sink; black finish (EP powder coated); weight approx. 1.5kg

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.

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

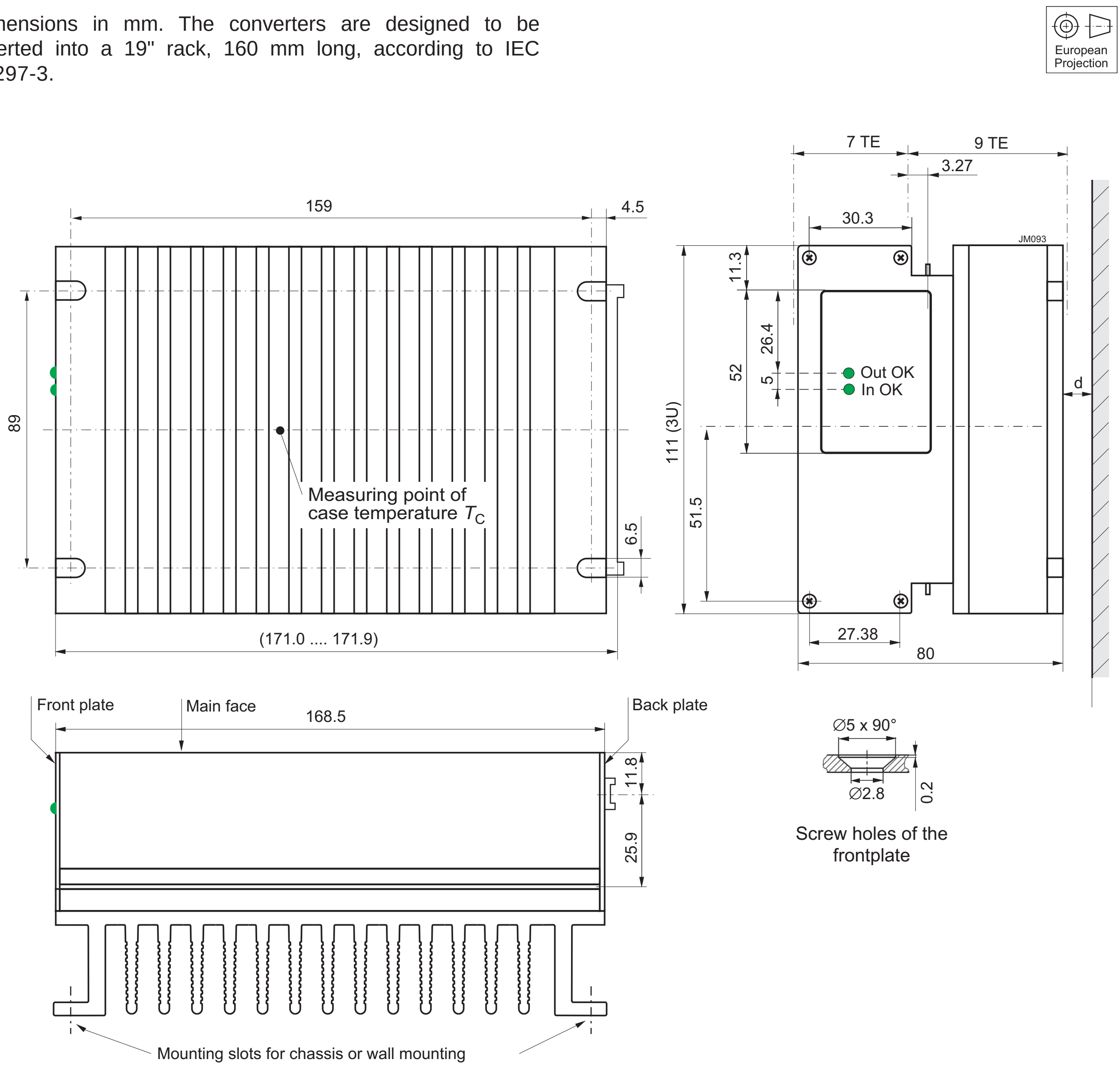


Fig. 19
Aluminium case of HRP2320 with heat sink; black finish (EP powder coated); weight approx. 18 kg

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.

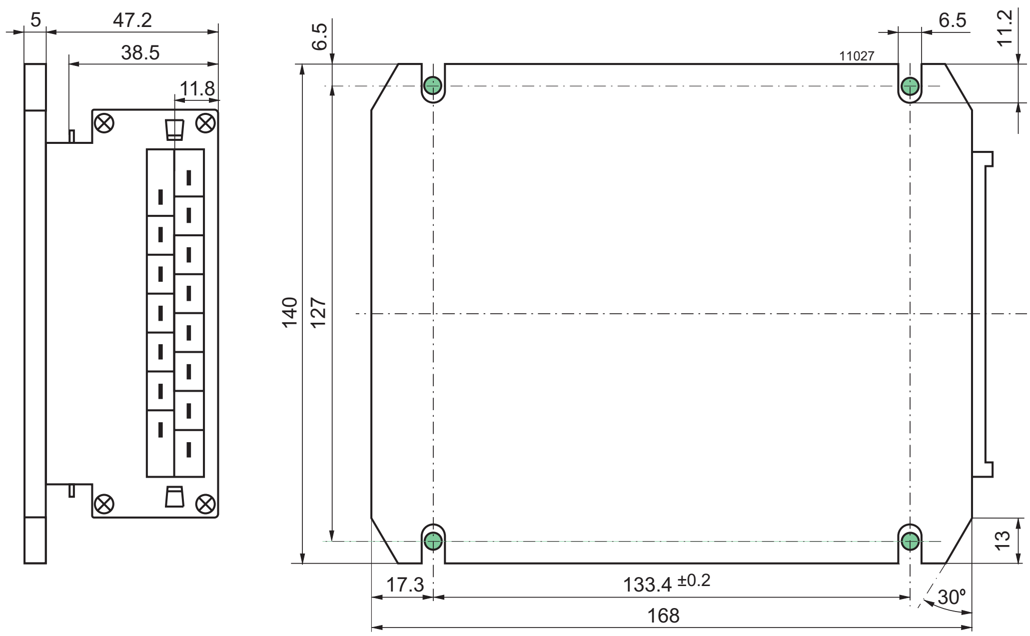
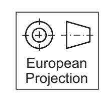


Fig. 22
Option B: Aluminum case S with large cooling plate; black finish (EP powder coated).
Suitable for front mounting.
Total weight approx. 1.5 kg



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

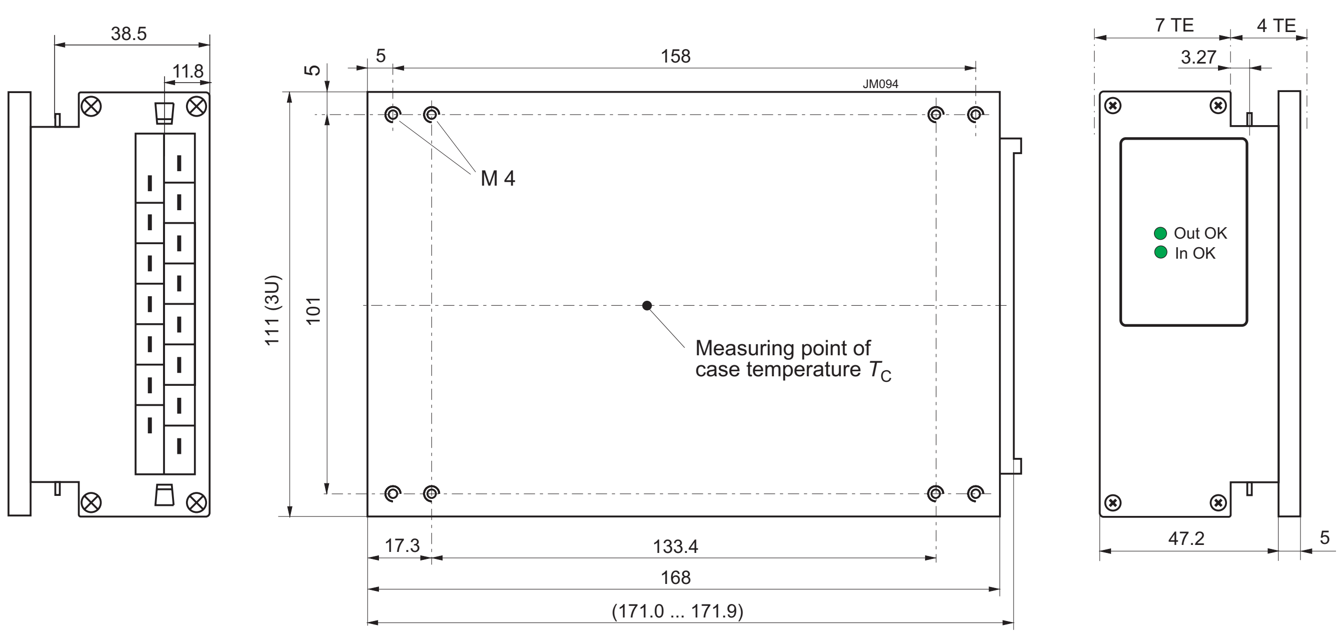


Fig. 20
Option B1: Aluminum case S with small cooling plate; black finish (EP powder coated).
Suitable for mounting with access from the backside.
Total weight approx. 1.4 kg.

Safety and Installation Instructions

Connector Pin Allocation

The connector pin allocation table defines the electrical potentials and the physical pin positions on the H15 or H15-S4 connector. The protective earth is connected by a leading pin (no. 24), ensuring that it makes contact with the female connector first.

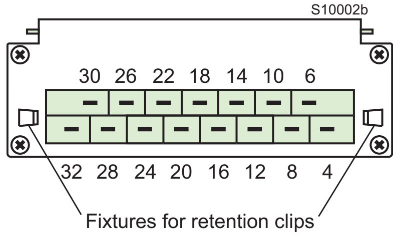


Fig. 21
View of module's male connectors

Table 12: Pin allocation

Pin no.	Name	Function
4	Vo1+	Pos. output 1
6	Vo2+	Pos. output 2
8	Vo1–	Neg. output 1
10	Vo2–	Neg. output 2
12	S1+	Pos. sense line
14	S1–	Neg. sense line
16	R	Output voltage adjust
18	T	Current share
20	D	Out OK
22 [2]	PE	Protection earth ⏚
24	PUL	Programmable undervoltage lockout
26 + 28	Vi+	Pos. input
30 + 32	Vi–	Neg. input

[2] 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. 22 (⏚) is connected with the case. For safety reasons it is essential to connect this pin reliably to protective earth.

Notes:

– The PUL function (pin 24) must be programmed to enable the outputs. PUL should be connected to Vi– (pins 30 + 32) by a resistor to adjust the start-up voltage; see table 3. Otherwise, the input current may become too high at low input voltage.

– Do not open the converters, or warranty will be invalidated.

– If the second output of double-output models is not used, connect it parallel with the main output.

Make sure that there is sufficient airflow available for convection cooling and verifiy 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 (in progress).

The converters correspond to Class I equipment and have been evaluated for:

- Building-in
- Basic insulation between input and case based on 250 VA and 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 converters are subject to manufacturing surveillance in accordance with the above mentioned standards and ISO 9001:2000. A CB-scheme is available.

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.

Table 13: Isolation

Characteristic		Input to case and output(s)	Output(s) to case	Output 1 to output 2	Unit
Electric strength test	Factory test >1 s	2.8 [1]	1.4	0.3	kVDC
	AC test voltage equivalent to factory test	2.0	1.0	0.21	kVAC
Insulation resistance at 500 VDC		>300	>300	>100 [2]	MΩ
Creapage distances		≥ 3.2 [3]	≥ 2.5	--	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] Tested at 150 VDC
[3] Input to outputs: 6.4 mm

Protection Degree

The protection degree is IP 20, provided that the female connector fitted to the converter.

Railway Application

The converters have been designed by observing the railway standards EN 50155, EN 50121-3-2, and EN 50121-4. All boards are coated with a protective lacquer.

Isolation and Protective Earth

The electric strength test is performed in the factory as routine test according to EN 50116 and IEC/EN 60950 and should not be repeated in the field. Power-One will not honor any warranty claims resulting from electric strength field tests. The resistance of the earth connection to the case (<0.1 Ω) is tested as well.

Description of Options

B, B1, B2 Cooling Plate

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*.

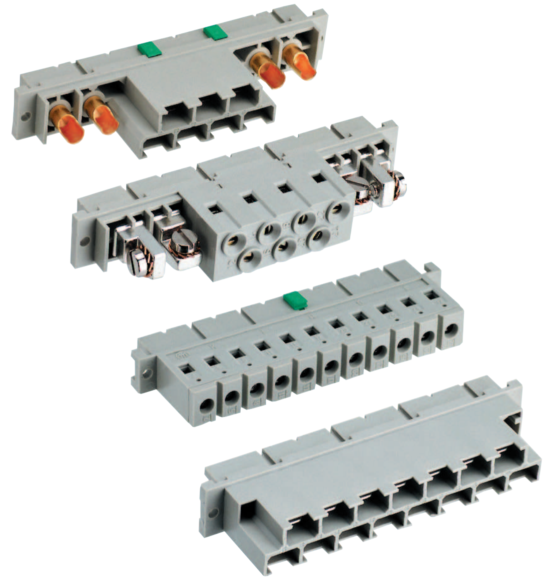
Option B2 is for customer-specific models with elongated case (for 220 mm DIN-rack depth).

Accessories

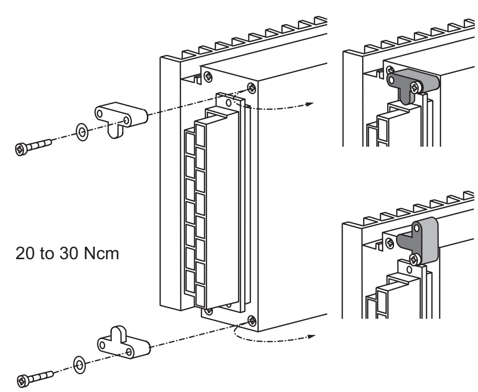
A variety of electrical and mechanical accessories are available including:

- Front panels for 19" DIN-rack: Schroff 16 TE / 3U [HZZ00831] and 16 TE /6U [HZZ00832], or Intermas 16 TE /3U [HZZ00731]
- Mating H15 and H15S4 connectors with screw, solder, faston or press-fit terminals.
- Coding clips for connector coding [HZZ00202]
- Connector retention clips (2x) [HZZ01209]
- Connector retention brackets CRB HKMS [HZZ01216]
- Cable connector housing (cable hood) KSG-H15/H15S4 [HZZ00141] as screw version. Also available as retention clip version [HZZ00142], or as a fully metallic housing.
- DIN-rail mounting assembly DMB-K/S [HZZ0615]
- Wall-mounting plate K02 [HZZ01213] 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 *Battery Charging/ Temperature Sensors*

For additional accessory product information, see the accessory data sheets listed with each product series or individual model listing at *www.power-one.com*.

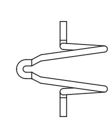


H15 and H15S4 female connectors with code key system

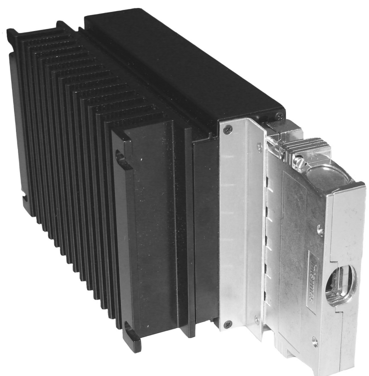


Connector retention brackets CRB HKMS

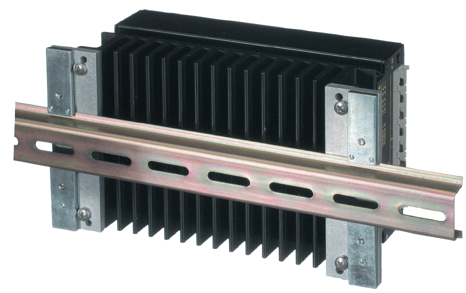
Different front panels



Connector retention clip

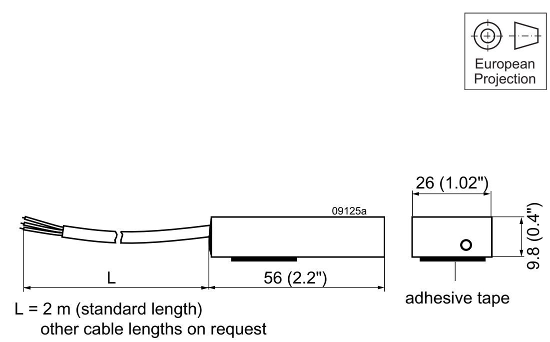


Metallic cable hood providing fire protection



DIN-rail mounting assembly DMB-K/S

Wall-mounting plate MOUNTINGPLATE-K02



Battery temperature sensor

NUCLEAR AND MEDICAL APPLICATIONS - Power-One products are not designed, intended for use in, or authorized for use as critical components in life support systems, equipment used in hazardous environments, or nuclear control systems without the express written consent of the respective divisional president of Power-One, Inc.

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.