

Features

- RoHS lead-free-solder and lead-solder-exempted products available
- Wide input voltage ranges up to 150 VDC
- 1, 2, 3, or 4 isolated outputs up to 96 V
- Class I equipment
- Very high efficiency
- Extremely low inrush current, hot swappable
- Excellent surge and transient protection
- Many output configurations available with flexible load distribution
- Externally adjustable output voltage
- Inhibit primary or secondary referenced
- Redundant operation (n+1), sense lines, current sharing option
- Extremely slim case (4TE, 20 mm), fully enclosed
- Hipot test voltage 2.1 kVDC
- All PCBs coated with protective lacquer
- Telecom-compatible input voltage range of DP models according to ETS 300132-2
- CompactPCI-compatible output voltage (xP4720)

Safety according to IEC/EN 60950-1 and UL 60950-1



Description

These extremely compact DC-DC converters incorporate all necessary input and output filtering, signalling, and protection features, which are required in the majority of applications. The converters provide important advantages such as flexible output power through primary current limitation, extremely high efficiency, excellent reliability, very low ripple and RFI noise levels, full input-to-output isolation, negligible inrush current, soft start, overtemperature protection, and input over-/undervoltage lockout.

The converter inputs are protected against surges and transients occurring on the source lines and cover a total input voltage range from 16 to 150 VDC with five different

types. The outputs are continuously open- and short-circuit proof.

Full system flexibility and n+1 redundant operating mode are possible due to series or parallel connection capabilities of the outputs under the specified conditions. When several converters are connected in parallel, the T option can be employed using a single wire connection between the converters to ensure good current sharing. LEDs at the front panel and an isolated output OK option indicate the status of the converter. Voltage suppressor diodes and an independent second control loop protect the outputs against an internally generated overvoltage.

The converters are designed using planar magnetics

Table of Contents

	Page		Page
Description	1	Immunity to Environmental Conditions	18
Model Selection	2	Mechanical Data	19
Functional Description	6	Safety and Installation Instructions	20
Electrical Input Data	7	Description of Options	23
Electrical Output Data	8	Accessories	24
Auxiliary Functions	14	EC Declaration of Conformity	25
Electromagnetic Compatibility (EMC)	16		

transformers and control circuits in hybrid technology. There are always two powertrains fitted to a converter, each consisting either of a single output with synchronous rectifier or of a controlled main output with a tracking second output. The output power may be flexibly distributed among the main and the tracking output of each powertrain. Close magnetic coupling in the transformers and output conductors together with circuit symmetry ensure tight tracking of the auxiliary output. The switching frequency is fixed.

As a modular power supply or as part of a distributed power

supply system, the low-profile design significantly reduces the required volume without sacrificing high reliability. The converters are particularly suitable for 19" rack systems occupying 3U/4TE only, but they can also be chassis-mounted by means of four screws. Connector type is H15 (or H15S2 for some single-output models). The fully enclosed black-coated aluminium case acts as heat sink and RFI shield and protects the converter together with the coating of all components against environmental impacts.

Model Selection

Note: Only standard models are listed. Other configurations are possible as well; contact Power-One.

Table 1a: Model types BP, CP

Output 1, 4			Output 2, 3			Input voltage range and efficiency				Options
$V_{O\text{nom}}$ [V]	$P_{O\text{nom}}$ [W]	$P_{O\text{max}}$ [W]	$V_{O\text{nom}}$ [V]	$P_{O\text{nom}}$ [W]	$P_{O\text{max}}$ [W]	η^2 [%]	$V_{i\text{min}} - V_{i\text{max}}^4$ 16–36 V	η^2 [%]	$V_{i\text{min}} - V_{i\text{max}}^4$ 33.6–75 V	
3.3	100	132	-	-	-	86	BP1101-9R	86	CP1101-9R	-7 D T ⁵ i K ⁸
5.1	122	183	-	-	-	87	BP1001-9R	88	CP1001-9R	
12	120	192	-	-	-	87.5	BP1301-9R	88.5	CP1301-9R	
15	120	194	-	-	-	88.5	BP1501-9R	88.5	CP1501-9R	
24	120	192	-	-	-	88	BP1601-9R	89	CP1601-9R	
3.3	50	66	5.1	61	91	86	BP2101-9R	86	CP2101-9R	B1, B3 G
5.1	61	91	5.1	61	91	87	BP2001-9R	88	CP2001-9R	
5.1	61	91	12	60	96	87	BP2020-9R	88	CP2020-9R	
12	60	96	12	60	96	87.5	BP2320-9R	88.5	CP2320-9R	
15	60	97	15	60	97	88.5	BP2540-9R	88.5	CP2540-9R	
24	60	96	24	60	96	88	BP2660-9R	89	CP2660-9R	
5.1	61	91	12, 12 ³	60 ¹	96 ¹	87	BP3020-9R	88	CP3020-9R	
5.1	61	91	15, 15 ³	60 ¹	96 ¹	87.5	BP3040-9R	88.5	CP3040-9R	
5.1	61	91	24, 24 ³	60 ¹	96 ¹	87.5	BP3060-9R	88.5	CP3060-9R	
5.1, 3.3 ⁷	30	50	12, 12 ³	60 ¹	96 ¹	-	BP4720-9R ⁶	-	CP4720-9R ⁶	
12, 12 ³	60 ¹	96 ¹	12, 12 ³	60 ¹	96 ¹	88	BP4320-9R	89	CP4320-9R	-7 D, i
15, 15 ³	60 ¹	96 ¹	15, 15 ³	60 ¹	96 ¹	88	BP4540-9R	89	CP4540-9R	B1, B3 G
24, 24 ³	60 ¹	96 ¹	24, 24 ³	60 ¹	96 ¹	88	BP4660-9R	89	CP4660-9R	

¹ The power of both outputs may in sum not exceed the total power for the specified ambient temperature.

² Min efficiency at $V_{i\text{nom}}$, $P_{O\text{nom}}$, $T_A = 25^\circ\text{C}$. Typical values are approx. 2% better.

³ Isolated tracking output ($\pm 5\%$ $V_{O\text{nom}}$, if each output is loaded with $\geq 5\%$ of $P_{O\text{nom}}$). Parallel or series configuration possible

⁴ Short deviations below $V_{i\text{min}}$ and beyond $V_{i\text{max}}$ according to EN 50155 possible

⁵ Only available for outputs with 3.3 V or 5.1 V

⁶ Compatible to CompactPCI[®] specification; for detailed specification contact Power-One.

⁷ Outputs 5.1 and 3.3 V have a common return.

⁸ H15 standard connector, rather than H15-S2 connector; applies for xP1101 and xP1001.

Table 1b: Model types DP, EP

Output 1, 4			Output 2, 3			Input voltage range and efficiency ²				Options
V _{o nom} [V]	P _{o nom} [W]	P _{o max} [W]	V _{o nom} [V]	P _{o nom} [W]	P _{o max} [W]	η ² [%]	V _{i min} - V _{i max} ⁴ 40 - 100.8 V ⁹	η ² [%]	V _{i min} - V _{i max} ⁴ 66 - 150 V	
3.3	100	132	-	-	-	86	DP1101-9R	86	EP1101-9R	-7 D T ⁵ i K ⁸ B1, B3 G
5.1	122	183	-	-	-	88	DP1001-9R	88	EP1001-9R	
12	120	192	-	-	-	88	DP1301-9R	87.5	EP1301-9R	
15	120	194	-	-	-	89	DP1501-9R	88	EP1501-9R	
24	120	192	-	-	-	88.5	DP1601-9R	87.5	EP1601-9R	
3.3	50	66	5.1	61	91	86	DP2101-9R	86	EP2101-9R	B1, B3 G
5.1	61	91	5.1	61	91	88	DP2001-9R	88	EP2001-9R	
5.1	61	91	12	60	96	88	DP2020-9R	87.5	EP2020-9R	
12	60	96	12	60	96	88	DP2320-9R	87.5	EP2320-9R	
15	60	97	15	60	97	89	DP2540-9R	88	EP2540-9R	
24	60	96	24	60	96	88.5	DP2660-9R	87.5	EP2660-9R	
5.1	61	91	12, 12 ³	60 ¹	96 ¹	87.5	DP3020-9R	87.5	EP3020-9R	
5.1	61	91	15, 15 ³	60 ¹	96 ¹	88	DP3040-9R	88	EP3040-9R	
5.1	61	91	24, 24 ³	60 ¹	96 ¹	88	DP3060-9R	88	EP3060-9R	
5.1, 3.3 ⁷	30	50	12, 12 ³	60 ¹	96 ¹	-	DP4720-9R ⁶	-	EP4720-9R ⁶	-7 D, i B1, B1 G
12, 12 ³	60 ¹	96 ¹	12, 12 ³	60 ¹	96 ¹	89	DP4320-9R	88	EP4320-9R	
15, 15 ³	60 ¹	96 ¹	15, 15 ³	60 ¹	96 ¹	89	DP4540-9R	88	EP4540-9R	
24, 24 ³	60 ¹	96 ¹	24, 24 ³	60 ¹	96 ¹	89	DP4660-9R	87	EP4660-9R	

Table 1c: Model types GP

Output 1, 4			Output 2, 3			Input voltage range and efficiency ²		Options
V _{o nom} [V]	P _{o nom} [W]	P _{o max} [W]	V _{o nom} [V]	P _{o nom} [W]	P _{o max} [W]	η ² [%]	V _{i min} - V _{i max} ⁴ 21.6 - 50.4 V	
3.3	100	132	-	-	-	86	GP1101-9R	-7 D T ⁵ i K ⁸ B1, B3 G
5.1	122	183	-	-	-	88	GP1001-9R	
12	120	192	-	-	-	87.5	GP1301-9R	
15	120	194	-	-	-	88	GP1501-9R	
24	120	192	-	-	-	87.5	GP1601-9R	
3.3	50	66	5.1	61	91	86	GP2101-9R	B1, B3 G
5.1	61	91	5.1	61	91	88	GP2001-9R	
5.1	61	91	12	60	91	87.5	GP2020-9R	
12	60	96	12	60	96	87.5	GP2320-9R	
15	60	97	15	60	97	88	GP2540-9R	
24	60	96	24	60	96	87.5	GP2660-9R	
5.1	61	91	12, 12 ³	60 ¹	96 ¹	87.5	GP3020-9R	
5.1	61	91	15, 15 ³	60 ¹	96 ¹	88.5	GP3040-9R	
5.1	61	91	24, 24 ³	60 ¹	96 ¹	88.5	GP3060-9R	
5.1, 3.3 ⁷	30	50	12, 12 ³	60 ¹	96 ¹	-	GP4720-9R ⁶	-7 D, i B1, B3 G
12, 12 ³	60 ¹	96 ¹	12, 12 ³	60 ¹	96 ¹	88	GP4320-9R	
15, 15 ³	60 ¹	96 ¹	15, 15 ³	60 ¹	96 ¹	88	GP4540-9R	
24, 24 ³	60 ¹	96 ¹	24, 24 ³	60 ¹	96 ¹	88	GP4660-9R	

¹ The power of both outputs may in sum not exceed the total power for the specified ambient temperature.

² Min efficiency at V_{i nom}, P_{o nom}, T_A = 25 °C. Typical values are approx. 2% better.

³ Isolated tracking output (±5% V_{o nom}, if each output is loaded with ≥5% of P_{o nom}). Parallel or series configuration possible

⁴ Short deviations below V_{i min} and beyond V_{i max} according to EN 50155 possible

⁵ Only available for outputs with 3.3 V or 5.1 V

⁶ Compatible to CompactPCI® specification; for detailed specification contact Power-One.

⁷ Outputs 5.1 and 3.3 V have a common return.

⁸ H15 standard connector, rather than H15-S2 connector; applies for xP1101 and xP1001.

⁹ According to ETS 300132-2 (DP models)

Part Number Description

C P 25 40-9R DT i B1

Input voltage $V_{i,nom}$:	
24 VDC	B
48 VDC	C
72 VDC	D
110 VDC	E
36 VDC	G
Series	P
Number of outputs:	
Single output	1
Double output	2
Triple output	3
Quadruple output	4
Nominal voltage output 1/output 4, $V_{o1/4,nom}$:	
3.3 V	1
5.1 V	0
12 V	3
15 V	5
24 V	6
other voltages ¹	7, 8
Other specifications and additional features ¹	01, ...99
Nominal voltage output 2/output 3, $V_{o2/3,nom}$:	
5.1 V	01
3.3 V	10
12 V	20
15 V	40
24 V	60
other voltages and features ¹	80, ... 99
Operational ambient temperature range T_A :	
-40 to 71 °C	-9
-25 to 71 °C (option)	-7
other ¹	0, -6
Output voltage adjust (auxiliary function)	R
Options:	
Out OK output	D ²
Current sharing	T ³
Isolated inhibit on secondary side	i ²
H15 standard connector	K ⁴
Heatsink 20 or 30 mm	B1, B3
RoHS compliant for all 6 substances	G ⁵

¹ Customer-specific models.

² Option D and option i exclude each other.

³ Only available for 3.3 V and 5 V outputs. Option T excludes option R, except for single-output models; refer to table 1.

⁴ Only available for single-output models with 3.3 V or 5 V output

⁵ G is always placed at the end of the part number. Consult Power-One for availability!

Example: CP 2540-9R: DC-DC converter, input voltage range 33.6 – 75 V, 2 regulated outputs each providing 15 V, equipped with R-control for output 1 and operating ambient temperature of -40 to 71 °C.

Note: All models exhibit the following auxiliary functions, which are not shown in the type designation: input and output filters, primary referenced inhibit, sense lines (single-, double- and triple-output models only), and LED indicators.

Product Marking

Basic type designation, applicable safety approval and recognition marks, CE mark, warnings, pin allocation, Power-One patents, company logo, specific type designation, input voltage range, nominal output voltage(s) and output current(s), degree of protection, batch no., serial no. and data code including production site, modification status and date of production. Identification of LEDs.

Output Configuration

The P Series allows high flexibility in output configuration to cover almost every individual requirement, by simply wiring outputs in parallel, in serial, or in independent configuration, as shown in the following diagrams.

Parallel or serial operation of several converters with equal output voltage is possible, however it is not advantageous to

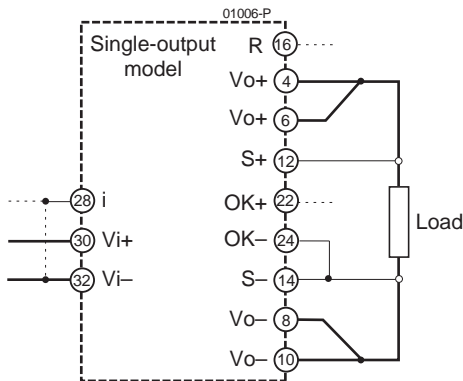


Fig. 1
Standard configuration (single-output model)

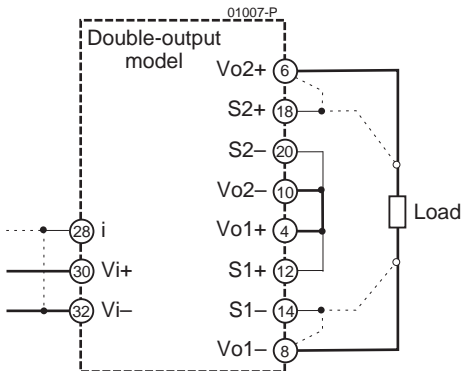


Fig. 2
Series output configuration of a double-output model.
The second output is fully regulated.

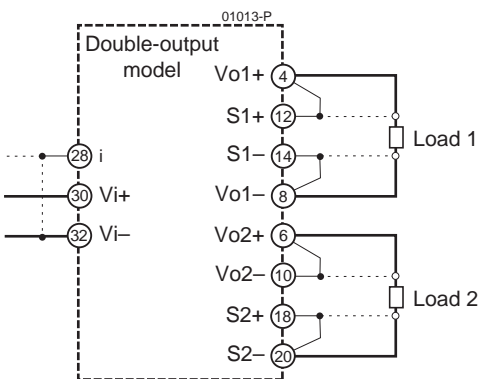


Fig. 3
Independent double-output configuration. Both outputs
are fully regulated

connect converters in parallel without measures to provide reasonable current sharing. Choose suitable single-output models, if available.

Note: Unused tracking outputs should be connected parallel to the respective regulated outputs.

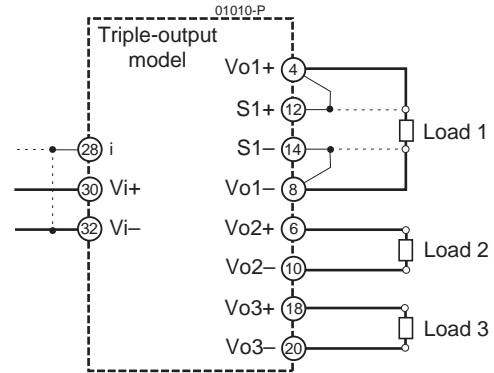


Fig. 4
Independent triple-output configuration. Output 3 is
tracking

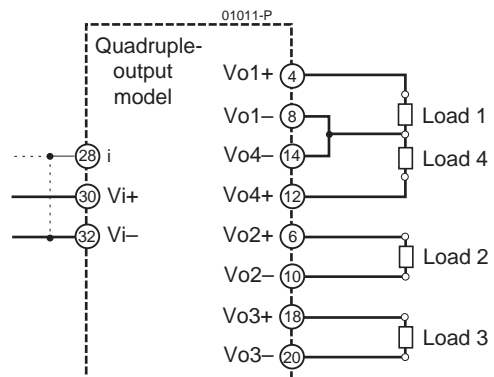


Fig. 5
Common ground configuration of output 1 with 4 and
independent configuration of output 2 and 3

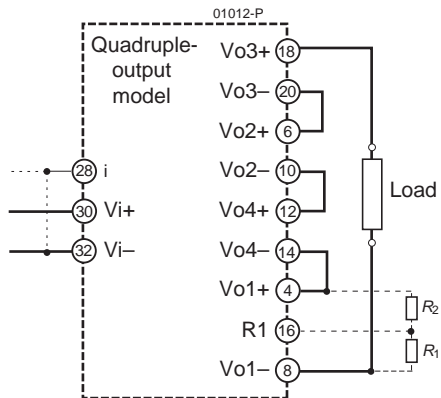


Fig. 6
Series configuration of all outputs ($V_o = 96\text{ V}$ for xP4660).
The R1-input influences only outputs 1 and 4. For the
values of R1 and R2 see Output Voltage Adjust.

Functional Description

The power supplies are equipped with two independent flight-forward converters, switching 180° phase-shifted to minimize the ripple current at the input. They use primary and secondary control circuits in hybrid technology. The two converters, called "powertrains" (PT), each generate either a single output with synchronous rectifier or two isolated outputs, one fully regulated and the other one tracking (semi-regulated), thus providing up to four output voltages. In some models, both outputs of a powertrain are connected in parallel internally.

The highly efficient input filter together with very low input capacitance causes very low and short inrush current. After transformer isolation and rectification the output filter reduces ripple and noise to a minimum without affecting the dynamic response. Outputs 3 and 4, if available, are tracking (semi-regulated) and rely upon the close magnetic coupling of the transformer and the output inductor together with the circuit symmetry for their voltage regulation. A current limitation is located on the primary side of each powertrain limiting the total output current from that powertrain in overload

conditions. This allows flex power operation of the outputs from each powertrain. All outputs can either be connected in series or in parallel; see *Electrical Output Data*.

An auxiliary converter provides the bias voltages for the primary and secondary referenced control logic and the option circuits. An oscillator generates a clock pulse of typically 307 kHz, which is fed to the control logic of each powertrain. The pulsewidth modulation and the magnetic feedback are provided by special ASICs. The converter is only enabled, if the input voltage is within the operating voltage range.

Double-output powertrains are equipped with a suppressor diode and an independent monitor sensing the output voltage of the tracking output. It shuts down the concerned powertrain, if an overvoltage occurs.

Single-output powertrains are protected by a suppressor diode.

The temperature of the heat sink is monitored and causes the converter to disable the outputs, until the temperature drops; then the converter will automatically resume.

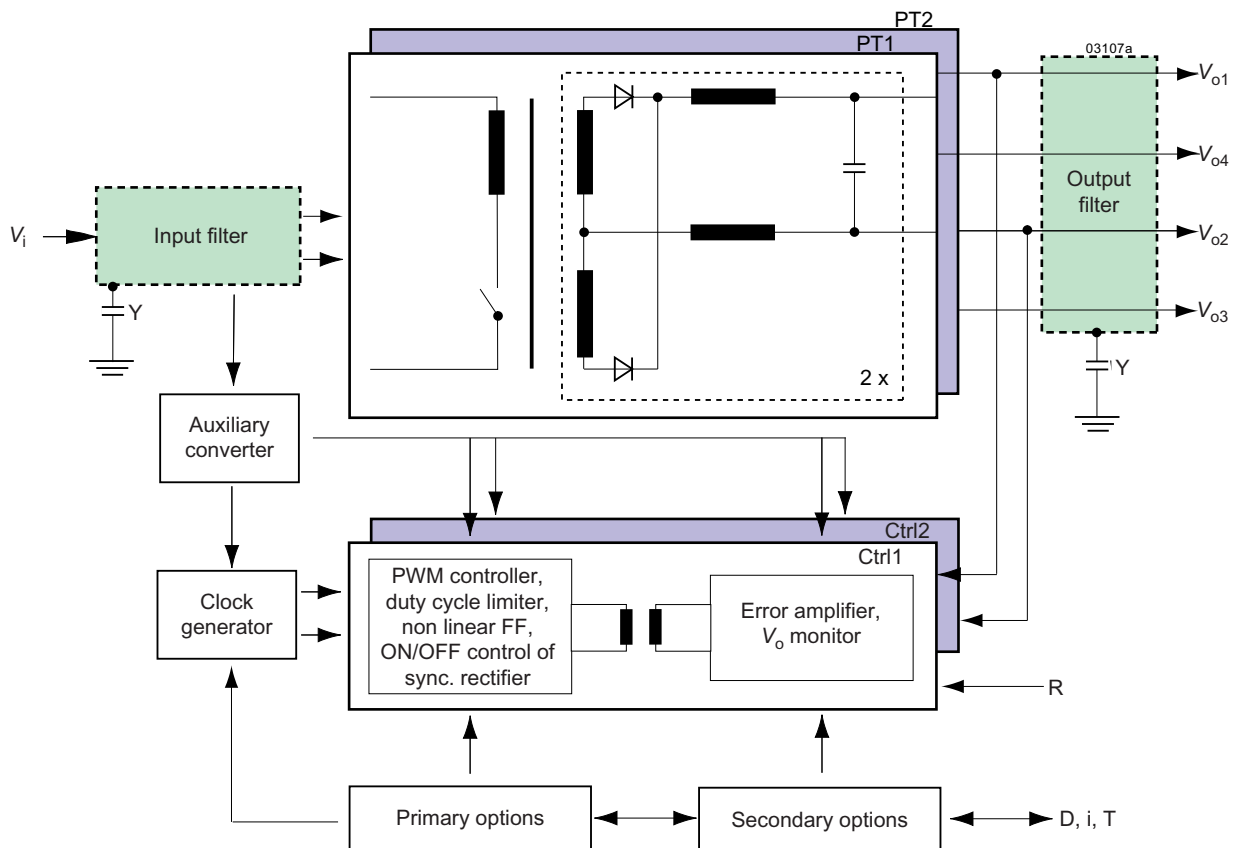


Fig. 7
Block diagram. Powertrains PT1 and PT2 have isolated outputs.
Pin allocation see table 12

Electrical Input Data

General Conditions:

- $T_A = 25^\circ\text{C}$, unless T_C is specified
- Sense lines connected directly at the connector, inhibit (28) connected to Vi– (32)
- R input open

Table 2a: Input data

Input		Conditions	BP			GP			CP			Unit
Characteristics			min	typ	max	min	typ	max	min	typ	max	
V_i	Operating input voltage	$I_o = 0 - I_{o\max}$ $T_C \text{ min} - T_C \text{ max}$	16		36	21.6		50.4	33.6		75	V
$V_{i\text{nom}}$	Nominal input voltage		24			36			48			
Short term excursions	For ≤ 100 ms	without lockout	14.4		40				28.8			
	For ≤ 2 s											
	For ≤ 3 s	with lockout				50			63			100
I_i	Typical input current ¹	$V_{i\text{nom}}, I_{o\text{nom}}$	5.6			3.7			2.8			A
P_{i0}	No-load input power ¹	$V_{i\text{min}}^1 - V_{i\text{max}}$	4		6.5	4		6.5	5		10	W
$P_{i\text{inh}}$	Idle input power ^{1 4}	$I_o = 0$	1		1.5	1		1.5	1		1.5	
I_{inrp}	Peak inrush current ²	$V_{i\text{max}}, I_{o\text{max}}$	61			64			66			A
$t_{\text{inr rise}}$	Rise time inrush		50			32			30			μs
t_r	Rise time inhibit ³	$I_{o\text{max}} - V_{i\text{nom}}$	5			5			5			ms
t_f	Fall time inhibit ³		2			2			2			
t_{don}	Start-up time ³	$0 \rightarrow V_{i\text{min}}, I_{o\text{max}}$	110						300			

Table 2b: Input data

Input		Conditions	DP ²			EP			Unit
Characteristics			min	typ	max	min	typ	max	
V_i	Operating input voltage	$I_o = 0 - I_{o\text{max}}$ $T_C \text{ min} - T_C \text{ max}$	40 ²		100.8	66		150	V
$V_{i\text{nom}}$	Nominal input voltage		72			110			
Short term excursions	For ≤ 100 ms	without lockout	36		115	57.6		184	
	For ≤ 2 s					168			
	For ≤ 3 s	with lockout	134			200			
I_i	Typical input current ¹	$V_{i\text{nom}}, I_{o\text{nom}}$	1.9			1.2			A
P_{i0}	No-load input power ¹	$V_{i\text{min}} - V_{i\text{max}}$	5		11	5		12	W
$P_{i\text{inh}}$	Idle input power ^{1 4}	$I_o = 0$	1		1.7	1.1		1.7	
I_{inrp}	Peak inrush current ²	$V_{i\text{max}}, I_{o\text{max}}$	57			65			A
$t_{\text{inr rise}}$	Rise time inrush		20			20			μs
t_r	Rise time inhibit ³	$I_{o\text{max}}, V_{i\text{nom}}$	5			5			ms
t_f	Fall time inhibit ³		2			1			
t_{don}	Start-up time ³	$0 \rightarrow V_{i\text{min}}, I_{o\text{max}}$				200			

¹ Typical values depending on model

² According to ETS 300132-2

³ See fig. 16

⁴ Converter inhibited

Input Fuse

A fuse mounted inside the converter protects against further damage in case of a failure. The fuse is not user-accessible. Reverse polarity at the input will cause the fuse to blow.

Table 3: Fuse specification

Model	Fuse type	Rating	Reference
BP	very fast blow	2× 10 A, 125 V	Littelfuse Pico 251
GP	very fast blow	2× 10 A, 125 V	Littelfuse Pico 251
CP	very fast blow	10 A, 125 V	Littelfuse Pico 251
DP	very fast blow	7 A, 125 V	Littelfuse Pico 251
EP	very fast blow	5 A, 250 V	Littelfuse Pico 263

Input Transient Protection

A VDR (Voltage Dependent Resistor), the input fuse, and a symmetrical input filter form an effective protection against input transients, which typically occur in most installations, but especially in battery-driven mobile applications.

Nominal battery voltages in use are: 24, 36, 48, 60, 72, 96, and 110 V. In most cases each nominal value is specified in a

tolerance of –30% to +25%, with short excursions to ±40% or even more.

In some applications, surges according to RIA 12 are specified in addition to those defined in IEC 60571-1 or EN 50155. The power supply must not switch off during these surges, and since their energy can practically not be absorbed, an extremely wide input range is required. The P Series input range has been designed and tested to meet these requirements; see *Electromagnetic Immunity*.

Input Under- / Overvoltage Lockout

If the input voltage is below approx. 0.9 $V_{i\ min}$ or exceeds approx. 1.1 $V_{i\ max}$, an internally generated inhibit signal disables the output(s). However, short extensions specified in EN 50155 will be withstood without shutdown.

Inrush Current

The inherent inrush current value is lower than specified in the standard ETS 300132-2 (ver. 3.1). The units operate with relatively small input capacitance resulting in low inrush current of short duration. As a result in a power-bus system the units can be hot plugged-in or disconnected causing negligible disturbance at the input side.

Electrical Output Data

General Conditions:

- $T_A = 25^\circ\text{C}$, unless T_C is specified.
- Sense lines connected directly at the connector, inhibit (28) connected to Vi– (32).
- R input not connected

Table 4a: Output data for single-output powertrains

Output		Single-output powertrain	3.3 V			5.1 V			12 V			Unit
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	
V_o	Output voltage ¹	$V_{i\ nom}, I_{o\ nom}$	3.28	3.3	3.32	5.07	5.1	5.13	11.94	12	12.06	V
V_{ow}	Worstcase output voltage	$V_{i\ min} - V_{i\ max}$ $T_{C\ min} - T_{C\ max}$ $I_o = 0 - I_{o\ max}$	3.24		3.35	5.02		5.18	11.82		12.18	
V_{OP}	Overvoltage protection ²		6.45	6.8		6.45	6.8		14.3	15	15.8	
$I_{o\ nom}$	Nominal output current			15			12			5		A
$I_{o\ max}$	Max. output current	$V_{i\ min} - V_{i\ max}$ $T_{C\ min} - T_{C\ max}$		20			18			8		
I_{oL}	Output current limit ³			22			19.8			8.8		
v_o	Output noise	Switch. frequ.	$V_{i\ nom}, I_{o\ max}$			5			15			mV _{pp}
		Total incl. spikes	BW = 20 MHz			20			30			
v_{od}	Dynamic load regulation	Voltage deviation	$V_{i\ nom}$ $I_{o\ max} \leftrightarrow 1/2 I_{o\ max}$			0.7			0.8			V
		Recovery time				0.4			0.3			
V_{otr}	Output voltage trim range (via R input)	$1.1 V_{i\ min} - V_{i\ max}$ $(0.1 - 1) I_{o\ max}$ $T_{C\ min} - T_{C\ max}$	1.79		3.63	2.75		5.61	6.5		13.2	V

¹ If the output voltages are increased above $V_{o\ nom}$ through R-input control or remote sensing, the output power should be reduced accordingly, so that $P_{o\ max}$ and $T_{C\ max}$ are not exceeded.

² Breakdown voltage of the incorporated suppressor diode at 10 mA (3.3 V, 5.1 V) or 1 mA (12 V). Exceeding this voltage might damage the suppressor diode.

³ See *Output Current Limitation and Increased Output Power at Reduced Temperature*

⁴ Measured according to IEC/EN 61204 with a probe described in annex A

⁵ Recovery time until V_o returns to ±1% of V_o ; see *Dynamic Load Regulation*.

Table 4b: Output data for single-output powertrains. General conditions as in table 4a

Output		Single-output powertrain	15 V			24 V			Unit
Characteristics		Conditions	min	typ	max	min	typ	max	
V_o	Output voltage ¹	$V_{i\ nom}, I_{o\ nom}$	14.93	15	15.08	23.88	24	24.12	V
V_{ow}	Worstcase output voltage	$V_{i\ min} - V_{i\ max}$ $T_{C\ min} - T_{C\ max}$ $I_o = 0 - I_{o\ max}$	14.78		15.23	23.64		24.36	
V_{oP}	Overvoltage protection ²		17.1	18	18.9	28.5	30	31.5	
$I_{o\ nom}$	Nominal output current			4			2.5		A
$I_{o\ max}$	Max. output current	$V_{i\ min} - V_{i\ max}$ $T_{C\ min} - T_{C\ max}$		6.5			4		
I_{oL}	Output current limit ³			7.2			4.4		
v_o	Output noise	Switch. frequ.	$V_{i\ nom}, I_{o\ max}$			15			mV _{pp}
		Total incl. spikes	BW = 20 MHz			40			
$v_{o\ d}$	Dynamic load regulation	Voltage deviation	$V_{i\ nom}$ $I_{o\ max} \leftrightarrow 1/2 I_{o\ max}$			1.2			V
t_d ⁵		Recovery time				0.2			ms
$V_{o\ tr}$	Output voltage trim range (via R input)	$1.1 V_{i\ min} - V_{i\ max}$ $(0.1 - 1) I_{o\ max}$ $T_{C\ min} - T_{C\ max}$	8.1		16.5	13		26.4	V

Table 4c: Output data for double-output powertrains. General conditions as in table 4a

Output		Double-output powertrain	12 V						Unit
Characteristics		Conditions	Main output			Tracking output			
			min	typ	max	min	typ	max	
V_o	Output voltage ¹	$V_{i\ nom}, I_{o\ nom}$	11.88	12	12.12	11.76	12	12.24	V
V_{ow}	Worstcase output voltage	$V_{i\ min} - V_{i\ max}$ $T_{C\ min} - T_{C\ max}$ $I_o = 0 - I_{o\ max}$	11.82		12.18	See Output Voltage Regulation			
V_{oP}	Overvoltage protection ²			none		14.3	15	15.8	
V_{oL}	Overvoltage limitation ⁶			none		14.4			
$I_{o\ nom}$	Nominal output current			2.5			2.5		A
$I_{o\ max}$	Max. output current	$V_{i\ min} - V_{i\ max}$ $T_{C\ min} - T_{C\ max}$		4			4		
I_{oL}	Output current limit ³			4.4			4.4		
v_o	Output noise	Switch. frequ.	$V_{i\ nom}, I_{o\ max}$			15			mV _{pp}
		Total incl. spikes	BW = 20 MHz			30			
$v_{o\ d}$	Dynamic load regulation	Voltage deviation	$V_{i\ nom}$ $I_{o\ max} \leftrightarrow 1/2 I_{o\ max}$			1.2			V
t_d ⁵		Recovery time				0.15			ms
$V_{o\ tr}$	Output voltage trim range (via R input)	$1.1 V_{i\ min} - V_{i\ max}$ $(0.1 - 1) I_{o\ max}$ $T_{C\ min} - T_{C\ max}$	6.5		13.2	See Output Voltage Regulation			V

¹ If the output voltages are increased above $V_{o\ nom}$ through R-input control or remote sensing, the output power should be reduced accordingly, so that $P_{o\ max}$ and $T_{C\ max}$ are not exceeded.

² Breakdown voltage of the incorporated suppressor diode at 1 mA. Exceeding this voltage might damage the suppressor diode.

³ See *Output Current Limitation and Increased Output Power at Reduced Temperature*

⁴ Measured according to IEC/EN 61204 with a probe described in annex A

⁵ Recovery time until V_o returns to $\pm 1\%$ of V_o ; see *Dynamic Load Regulation*

⁶ Output voltage limitation by an additional control loop

Table 4d: Output data for double-output powertrains. General conditions as in table 4a

Output		Double-output powertrain	15 V						24 V						Unit
			Main output			Tracking output			Main output			Tracking output			
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	
V_o	Output voltage ¹	$V_{i,nom}, I_{o,nom}$	14.85	15	15.15	14.7	15	15.3	23.76	24	24.24	23.52	24	24.48	V
V_{ow}	Worstcase output voltage	$V_{i,min} - V_{i,max}$ $T_{C,min} - T_{C,max}$ $I_o = 0 - I_{o,max}$	14.78		15.23	See Output Voltage Regulation			23.64		24.36	See Output Voltage Regulation			
$V_{o,P}$	Overvoltage protection ²		none			17.1	18	18.9	none			28.5	30	31.5	
$V_{o,L}$	Overvoltage limitation ⁶		none			17.6			none			28.8			
$I_{o,nom}$	Nominal output current		2			2			1.25			1.25			A
$I_{o,max}$	Max. output current	$V_{i,min} - V_{i,max}$ $T_{C,min} - T_{C,max}$	3.25			3.25			2			2			
$I_{o,L}$	Output current limit ³		3.6			3.6			2.2			2.2			
v_o	Output noise	Switch. frequ.	15			15			15			15			mV _{pp}
		Total incl. spikes	40			40			70			70			
$v_{o,d}$	Dynamic load regulation	Voltage deviation	1.2			1.2			0.5			0.5			V
		Recovery time	0.2			0.2			0.15			0.15			
$V_{o,tr}$	Output voltage trim range (via R input)	$1.1 V_{i,min} - V_{i,max}$ $(0.1 - 1) I_{o,max}$ $T_{C,min} - T_{C,max}$	8.1		16.5	See Output Voltage Regulation			13		26.4	See Output Voltage Regulation			V

- ¹ If the output voltages are increased above $V_{o,nom}$ through R-input control or remote sensing, the output power should be reduced accordingly, so that $P_{o,max}$ and $T_{C,max}$ are not exceeded.
- ² Breakdown voltage of the incorporated suppressor diode at 1 mA. Exceeding this voltage might damage the suppressor diode.
- ³ See *Output Current Limitation* and *Increased Output Power at Reduced Temperature*
- ⁴ Measured according to IEC/EN 61204 with a probe described in annex A
- ⁵ Recovery time until V_o returns to $\pm 1\%$ of V_o ; see *Dynamic Load Regulation*
- ⁶ Output voltage limitation by an additional control loop

Parallel and Series Connection

The first outputs of power trains with equal nominal output voltage can be connected in parallel. Where available, we recommend ordering of option T.

Any output can be connected in series with any other output. If the main and the tracking output of the same power train are connected in series, consider that the effect of the R-input is doubled.

Notes:

If tracking outputs are not used, connect them in parallel to the respective regulated main output.

Connection of several outputs in parallel should include measures to approximate all output currents. 3.3 and 5 V outputs with option T have current share pins (T or T1), which must be interconnected. For other outputs, the load lines should exhibit similar resistance. Parallel connection of regulated outputs without such precautions is not recommended.

The maximum output current of a serial-connected outputs is limited by the output with the lowest current limit.

Rated output voltages above 48 V (SELV = Safety Extra Low Voltage) require additional safety measures in order to comply with international safety requirements.

Parallel operation of two double-output converters with series-connected outputs is shown in fig. 9. The link

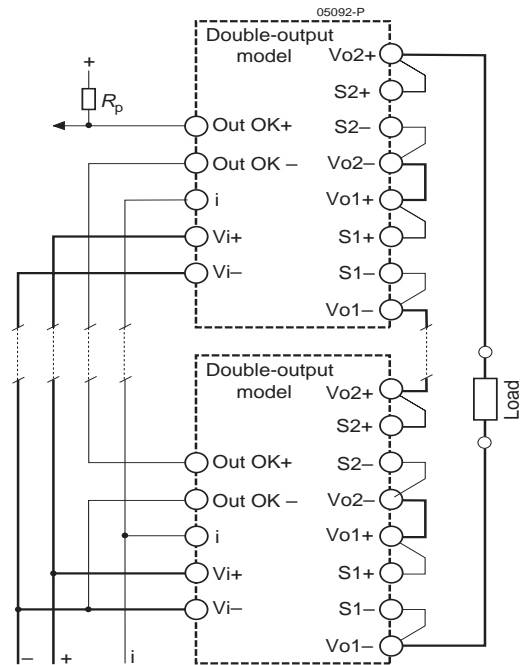


Fig. 8
Series connection of double-output models. Sense lines connected at the connector.

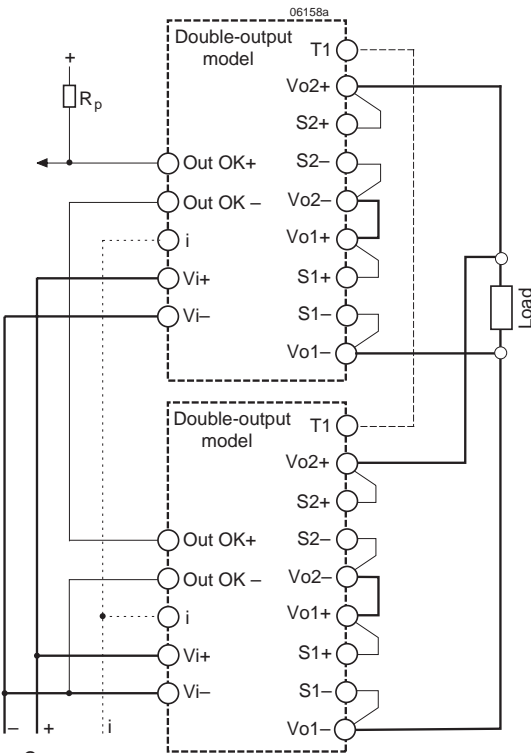


Fig. 9
Parallel operation of 2 double-output converters with series-connected outputs.

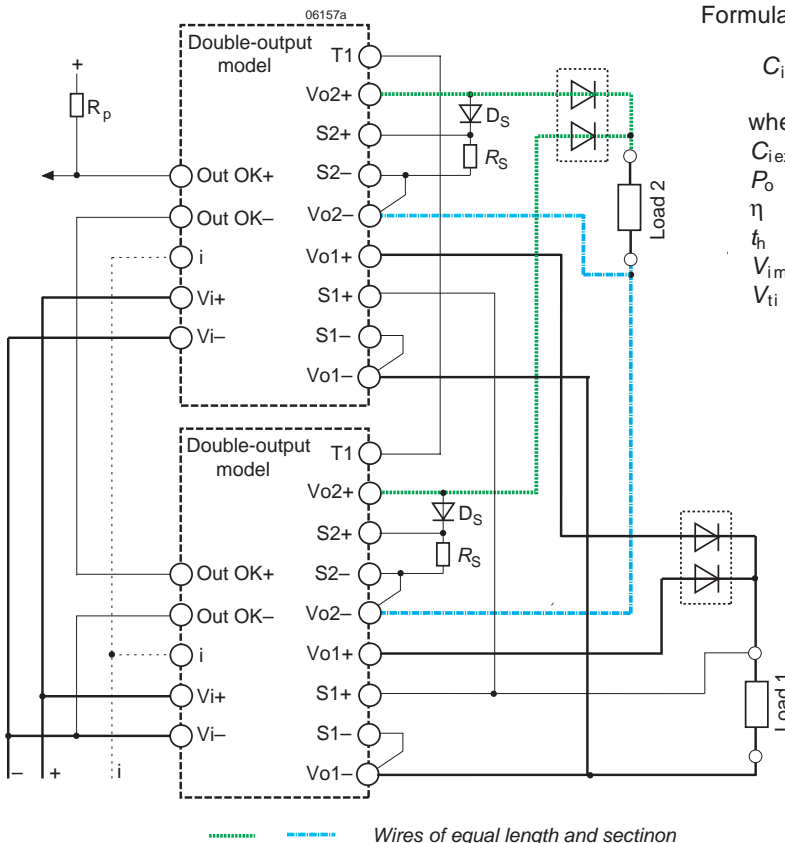


Fig. 10
Redundant configuration

between the T1 pins ensures proper current sharing, even though only the first outputs are influenced. Sense lines are connected directly at the connector, and load lines have equal length and section.

Redundant Systems

An example of a redundant system using converters with 2 regulated outputs (xP2020) is shown in fig. 10. Load 1 is powered with 5.1 V and load 2 with 12 V.

The converters are separated with ORing diodes. If one converter fails, the remaining one still delivers the power to the loads. If more power is needed, the system may be extended to more parallel converters (n+1 redundancy).

Current sharing of the 5.1 V outputs is ensured by interconnected T1 pins, whereas the sense lines are connected after the ORing diodes to maintain the correct output voltage.

For the 12 V outputs, no current feature is available. As a result, 2 little diodes D_s (loaded by little resistors R_s) simulate the voltage drop of the ORing diodes. Reasonable current sharing is provided by load lines of equal length and section.

Hold-up Time

The converters provide virtually no hold-up time. If a hold-up time is required, use external output capacitors or decoupling diodes and input capacitors of adequate size.

Formula for additional external input capacitor:

$$C_{i \text{ ext}} = \frac{2 \cdot P_o \cdot t_h \cdot 100}{(V_{ti}^2 - V_{i \text{ min}}^2) \cdot \eta}$$

whereas:

- $C_{i \text{ ext}}$ = external input capacitance [mF]
- P_o = output power [W]
- η = efficiency [%]
- t_h = hold-up time [ms]
- $V_{i \text{ min}}$ = minimum input voltage [V]
- V_{ti} = threshold level [V]

Output Voltage Regulation

Line and load regulation of the regulated outputs is so good that input voltage and output current have virtually no influence to the output voltage.

However, if the tracking output is not loaded, the second control loop may slightly reduce the voltage of the main output. Thus, unused tracking outputs should be connected in parallel to the respective main output.

The dynamic load regulation is shown in fig. 11.

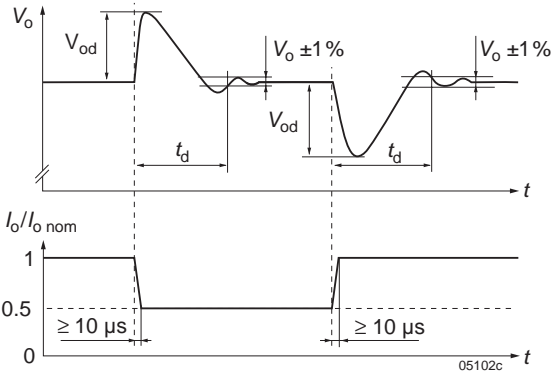


Fig. 11
Typical dynamic load regulation of output voltage

Tracking Outputs

The main outputs 1 and 2 are regulated to $V_{o,nom}$ independent of the output current. If the loads on outputs 3 and 4 are too low (<10% of $I_{o,nom}$), their output voltage tends to rise. V_{o3} and V_{o4} depend upon the load distribution: If all outputs are loaded with at least 10% of $I_{o,nom}$, V_{o3} and V_{o4} remain within $\pm 5\%$ of $V_{o,nom}$. The following diagrams show the regulation of the tracking outputs under different load conditions up to the current limit. If $I_{o1} = I_{o4}$ and $I_{o2} = I_{o3}$ or if the tracking outputs are connected in series with their respective regulated outputs, then V_{o3} and V_{o4} remain within $\pm 1\%$ of $V_{o,nom}$ provided that the load is at least $I_{o,min}$. A 2nd control loop protects the tracking outputs against overvoltage by reducing the voltage of the respective regulated main output.

Because the P Series uses main transformers and main chokes in planar technology, the tracking outputs follow the main outputs very closely.

Note: If the tracking output (V_{o3} or V_{o4}) is not loaded, it should be connected in parallel to the respective main output (V_{o3} parallel to V_{o2} , V_{o4} parallel to V_{o1}).

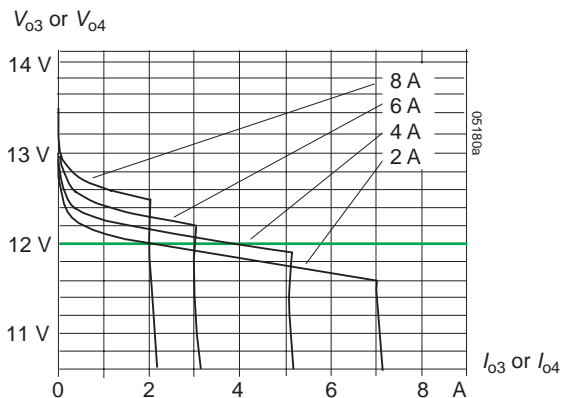


Fig. 12
12 V tracking output V_{o4} versus I_{o4} (powertrain 1) or V_{o3} versus I_{o3} (powertrain 2). $V_i = V_{i,nom}$

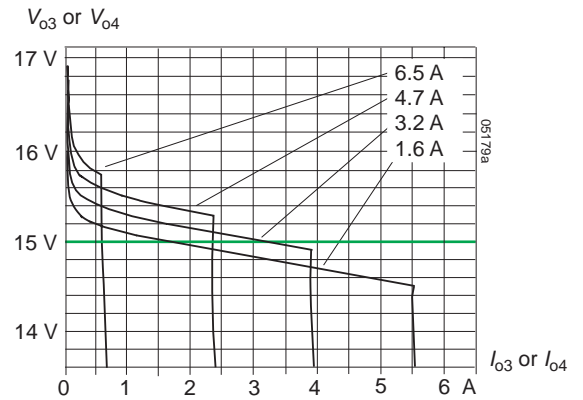


Fig. 13
15 V tracking output $V_o = f(I_o)$, $V_i = V_{i,nom}$

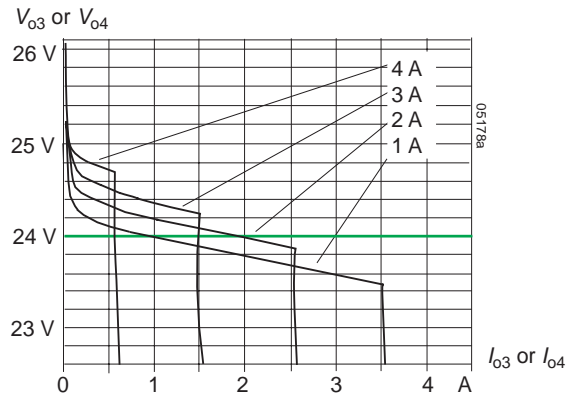


Fig. 14
24 V tracking output $V_o = f(I_o)$, $V_i = V_{i,nom}$

Hot Swap

Important: For applications using the hot swap capabilities, dynamic output voltage changes during plug-in and plug-out operations should be considered.

Output Current Limitation

All outputs are continuously protected against open-circuit (no load) and short-circuit by an electronic current limitation.

Single- and double-output powertrains have a rectangular current limitation characteristic. In double output powertrains only the total current is limited allowing free choice of load distribution between the two outputs of each power train up to a total $I_{o1} + I_{o4} = I_{o,max}$ or $I_{o2} + I_{o3} = I_{o,max}$.

Thermal Considerations

If a converter is mounted upright in free air, allowing unrestricted convection cooling, and is operated at its nominal input voltage and output power at $T_{A \text{ max}}$ (see table *Temperature specifications*), the temperature measured at the measurement point on the case T_C (see *Mechanical Data*) will approach $T_{C \text{ max}}$ after an initial warm-up phase. However the relationship between T_A and T_C depends heavily on the operating conditions and system integration. The thermal conditions are influenced significantly by the input voltage, the output current, airflow, and the temperature of the adjacent elements and surfaces. $T_{A \text{ max}}$ is therefore contrary to $T_{C \text{ max}}$ only an indicative value.

Thermal Protection

A temperature sensor fitted on the main PCB disables the output, when the case temperature exceeds $T_{C \text{ max}}$. The converter automatically resumes, when the temperature drops below this limit. A temperature sensor on each power train reduces the output current limit of that power train, when the temperature exceeds a safe level.

Output Power at Reduced Temperature

Operating the converters with an output current between $I_{o \text{ nom}}$ and $I_{o \text{ max}}$ requires a reduction in maximum ambient temperature or forced air cooling in order to keep T_C below 95 °C. When $T_{C \text{ max}}$ is exceeded, the thermal protection is activated and disables the outputs.

Note: Forced cooling or an additional heat sink can improve the reliability or allow T_A to go beyond $T_{A \text{ max}}$, provided that $T_{C \text{ max}}$ is not exceeded. In rack systems without proper thermal management the converters should not be packed too closely together! In such cases the use of a 5 or 6TE front panel is recommended.

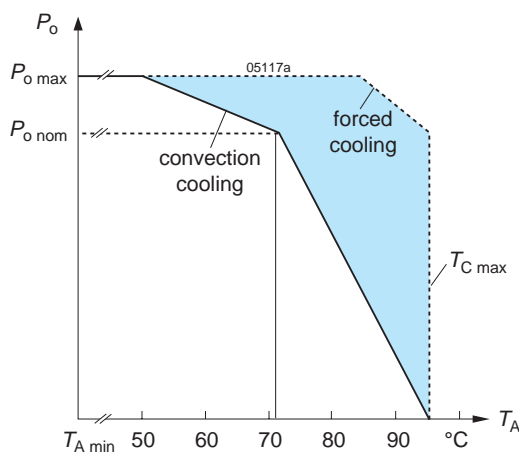


Fig. 15
Output power derating versus T_A .

Auxiliary Functions

Primary Inhibit (Remote On / Off)

The inhibit input enables (logic low, pull down) or disables (logic high, pull up or open-circuit) the output, if a logic signal (TTL, CMOS) is applied. In systems consisting of several converters, this feature may be used to control the activation sequence by logic signals or to enable the power source to start up, before full load is applied.

Note: If this function is not used, pin 28 must be connected with pin 32, otherwise the internal logic will disable the output.

Table 5: Inhibit characteristics

Characteristic		Conditions	min	typ	max	Unit
V_{inh}	Inhibit Voltage	$V_o = on$	$V_{i min} - V_{i max}$	-50	0.8	V
		$V_o = off$	$T_C min - T_C max$	2.4	50	
I_{inh}	Inhibit current	$V_{inh} = -50 V$		-1000		μA
		$V_{inh} = 0 V$		-40		
		$V_{inh} = 50 V$		900		

Note: The secondary referenced inhibit function, refers to the description of option i.

The output response after enabling or disabling the output by the inhibit input is shown in the figure below. See also *Input Data*.

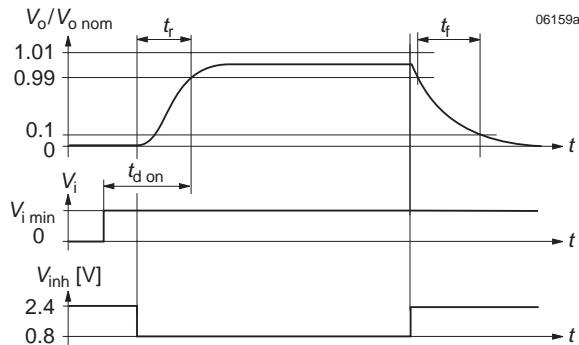


Fig. 16
Output response as a function of V_i (on/off switching) or inhibit control

Output Voltage Adjust of V_{o1} and V_{o4}

Note: With open R input, $V_o = V_{o nom}$.

The converters offer adjust of the voltage of powertrain 1. Powertrain 2 can not be adjusted. The programming is performed either by an external control voltage V_{ext} or an external resistor R_1 or R_2 , connected to the R-input. Trimming is limited to the values given in the table *Electrical Output Data*.

Note: With open R input, $V_o = V_{o nom}$.

With double output powertrains, both outputs are influenced by the R-input setting simultaneously.

Caution: To prevent damage, V_{ext} should not exceed 20 V, nor be negative.

Note: If output voltages are set higher than $V_{o nom}$, the output currents should be reduced accordingly, so that the maximum specified output power is not exceeded.

a) Adjustment by means of an external voltage:

$$V_{ext} \approx \frac{2.72 V_{o1}}{V_{o nom}} - 0.28 V$$

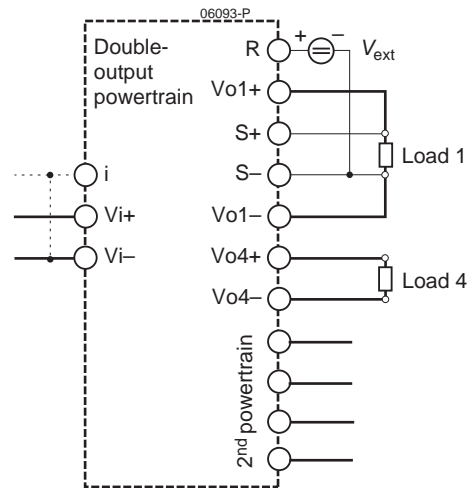


Fig. 17
Output adjust of V_{o1} and V_{o4} with an external voltage V_{ext} . The other outputs are not influenced.

b) Adjustment by means of an external resistor:

The resistor can either be connected between the pins R (16) and S- (14) to set $V_o < V_{o nom}$, or between the pins R (16) and S+ (12) to set $V_o > V_{o nom}$.

Note: R inputs of n converters with paralleled outputs may be connected together, but if only one external resistor is used, its value should be R_1/n or R_2/n .

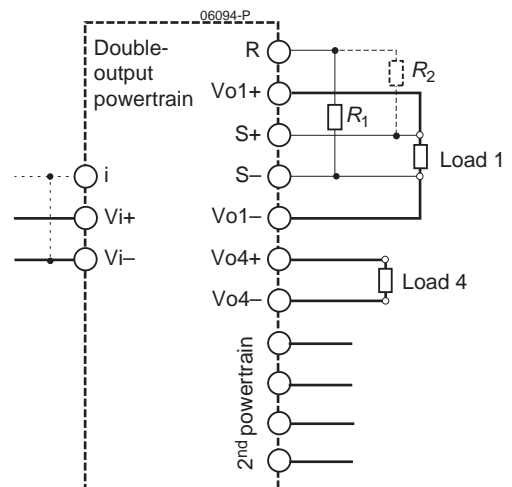


Fig. 18
Output adjust of V_{o1} and V_{o4} using R_1 or R_2 . The other outputs are not influenced.

Table 6a: R_1 for $V_o < V_{o\text{ nom}}$; approximate values ($V_{i\text{ nom}}$, $I_{o\text{ nom}}$, series E 96 resistors); R_2 not fitted

$V_{o\text{ nom}} = 3.3\text{ V}$		$V_{o\text{ nom}} = 5.1\text{ V}$		$V_{o\text{ nom}} = 12\text{ V}$			$V_{o\text{ nom}} = 15\text{ V}$			$V_{o\text{ nom}} = 24\text{ V}$		
V_o (V)	R_1 [k Ω]	V_o (V)	R_1 [k Ω]	V_o [V] ¹		R_1 [k Ω]	V_o [V] ¹		R_1 [k Ω]	V_o [V] ¹		R_1 [k Ω]
2.0	5.62	4.0	14.0	6.5	13.0	4.22	8.0	16.0	4.12	14.0	28.0	5.23
2.1	6.49	4.1	15.8	7.0	14.0	5.11	8.5	17.0	4.75	15.0	30.0	6.19
2.2	7.50	4.2	18.2	7.5	15.0	6.19	9.0	18.0	5.49	16.0	32.0	7.5
2.3	8.66	4.3	21.0	8.0	16.0	7.5	9.5	19.0	6.34	17.0	34.0	9.31
2.4	10.2	4.4	24.3	8.5	17.0	9.09	10.0	20.0	7.5	18.0	36.0	11.5
2.5	12.1	4.5	29.4	9.0	18.0	11.5	10.5	21.0	8.87	19.0	38.0	14.7
2.6	14.3	4.6	36.5	9.5	19.0	14.7	11.0	22.0	10.5	20.0	40.0	19.6
2.7	17.4	4.7	47.5	10.0	20.0	19.6	11.5	23.0	12.7	20.5	41.0	22.6
2.8	22.1	4.8	63.4	10.5	11.0	27.4	12.0	24.0	15.4	21.0	42.0	27.4
2.9	28.7	4.9	97.6	11.0	22.0	43.2	12.5	25.0	29.6	21.5	43.0	34.0
3.0	39.2	5.0	200.0	11.5	23.0	88.7	13.0	26.0	25.5	22.0	44.0	43.2
3.1	61.9						13.5	27.0	34.8	22.5	45.0	59.0
3.2	12.7						14.0	28.0	54.9	23.0	46.0	88.7
							14.5	29.0	110.0	23.5	47.0	182.0

Table 6b: R_2 for $V_o > V_{o\text{ nom}}$; approximate values ($V_{i\text{ nom}}$, $I_{o\text{ nom}}$, series E 96 resistors); R_1 not fitted

$V_{o\text{ nom}} = 3.3\text{ V}$		$V_{o\text{ nom}} = 5.1\text{ V}$		$V_{o\text{ nom}} = 12\text{ V}$			$V_{o\text{ nom}} = 15\text{ V}$			$V_{o\text{ nom}} = 24\text{ V}$		
V_o (V)	R_1 [k Ω]	V_o (V)	R_1 [k Ω]	V_o [V] ¹		R_1 [k Ω]	V_o [V] ¹		R_1 [k Ω]	V_o [V] ¹		R_1 [k Ω]
3.4	47.5	5.2	226.0	12.2	24.4	1100.0	15.3	30.6	1130.0	24.5	49.0	1820.0
3.5	24.3	5.3	115.0	12.4	24.8	499.0	15.5	31.0	665.0	25.0	50.0	909.0
3.6	16.3	5.4	78.7	12.6	25.2	332.0	15.7	31.4	475.0	25.5	51.0	604.0
		5.5	59.0	12.8	25.6	255.0	16.0	32.0	332.0	26.0	52.0	464.0
		5.6	48.7	13.0	26.0	205.0	16.2	32.4	280.0	26.4	52.8	392
				13.2	26.4	174.0	16.5	33.0	232.0			

¹ First column: single output powertrains or double output powertrains with separated/paralleled outputs, second column: outputs in series connection.

Sense Lines

Important: Sense lines should always be connected. Incorrectly connected sense lines may damage the converter. If sense lines are left open-circuit, the output voltages will be inaccurate.

This feature enables compensation of voltage drop across the connector contacts and the load lines including ORing diodes in true redundant systems.

Applying generously dimensioned cross-section load leads avoids troublesome voltage drop. To minimize noise pick-up, wire sense lines parallel or twisted to the respective output line. To be sure, connect the sense lines directly at the female connector.

The voltage difference between any sense line and its respective power output pin (as measured on the connector) should not exceed the following values at nominal output voltage.

Table 7: Voltage compensation allowed using sense lines

Output type	Total drop	Negative line drop
3.3, 5.1 V output	<0.5 V	<0.25 V
12, 15, 24 V output	<1.0 V	<0.5 V

Electromagnetic Compatibility (EMC)

A metal oxide resistor (VDR) together with an input fuse and filter form an effective protection against high input transient

voltages, which typically occur in most installations, but especially in battery-driven mobile applications. The P series has been successfully tested to the following specifications:

Electromagnetic Immunity

Table 8: Immunity type tests

Phenomenon	Standard	Level	Coupling mode ¹	Value applied	Waveform	Source imped.	Test procedure	In oper.	Perf. crit. ²
Supply related surge	RIA 12	B	+i/-i	$1.5 \cdot V_{batt}$	0.1/1/0.1 s	0.2 Ω	1 positive surge	yes	A
	EN 50155			$1.4 \cdot V_{batt}$		1 Ω			
Direct transients	RIA 12 EN 50155: 1995	D ⁴	-i/c, +i/-i	1800 V _p	5/50 μ s	5 Ω	5 pos. and 5 neg. impulses	yes	B
Indirect coupled transients		G ⁵		8400 V _p	0.05/0.1 μ s	100 Ω			
		H	1800 V _p	5/50 μ s	330 Ω				
		L	8400 V _p	0.05/0.1 μ s					
Electrostatic discharge (to case)	IEC/EN 61000-4-2	4 ⁶	contact discharge	8000 V _p	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	B
Electromagnetic field, mobile phone	IEC/EN 61000-4-3	x ⁷	antenna	20 V/m	AM 80% 1 kHz	n.a.	80 – 1000 MHz	yes	A
	ENV 50204	x ¹⁰	antenna	20 V/m	50% duty cycle 200 kHz repetition		900 \pm 5 MHz	yes	A
Electrical fast transients/burst	IEC/EN 61000-4-4	4 ⁸	capacitive, o/c	2000 V _p	bursts of 5/50 ns 5 kHz over 15 ms; burst period: 300 ms	50 Ω	60 s positive 60 s negative transients per coupling mode	yes	B
			direct,+i/c, -i/c, +i/-i	4000 V _p					
Surges	IEC/EN 61000-4-5	3 ³	+i/c, -i/c	2000 V _p	1.2/50 μ s	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	B
		2 ³	+i/-i	1000 V _p		2 Ω			
Conducted disturbances	IEC/EN 61000-4-6	3 ⁹	i, o, signal wires	10 VAC (140 dB μ V)	AM 80% 1 kHz	150 Ω	0.15 – 80 MHz	yes	A

¹ i = input, o = output, c = case.

² A = Normal operation, no deviation from specs, B = Temporary deviation from specs possible.

³ Measured with an external input capacitor (to prevent oscillations)

⁴ Corresponds to EN 50155:2001, waveform A, and EN 50121-3-2:2000, table 7.2.

⁵ Corresponds to EN 50155:2001, waveform B.

⁶ Corresponds to EN 50121-3-2:2000, table 9.2.

⁷ Corresponds to EN 50121-3-2:2000, table 9.1, and EN 50121-5-2:2000, table 1.1.

⁸ Corresponds to EN 50121-3-2:2000, table 7.1.

⁹ Corresponds to EN 50121-3-2:2000, table 7.4.

¹⁰ Fulfills also EN 50121-5:2000, table 1.2, where ENV 50204 is referenced.

Electromagnetic Emissions

Table 9: Emissions at $V_{i\text{ nom}}$ and $I_{o\text{ nom}}$

Types	Level according to EN 55011 / EN 55022	
	≤30 MHz	>30 MHz
BP 2320	B	
CP 1001	B	
EP 3020	B	
EP 4660	B	

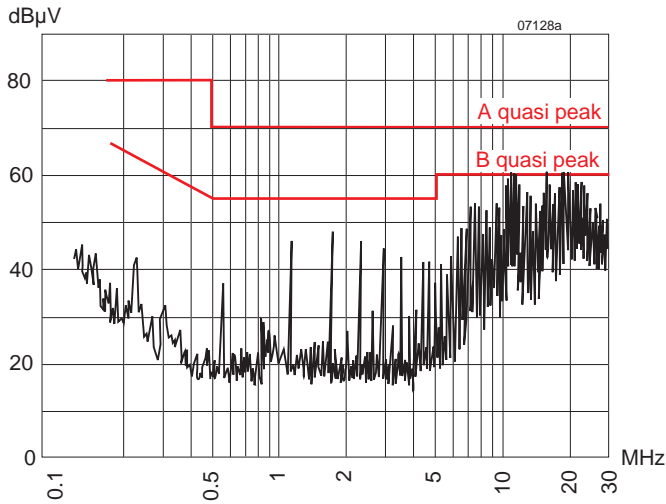


Fig. 19
BP 2320-7RD
Typical disturbance voltage at the input ($V_{i\text{ nom}}$, $I_{i\text{ nom}}$, resistive load, quasi peak).

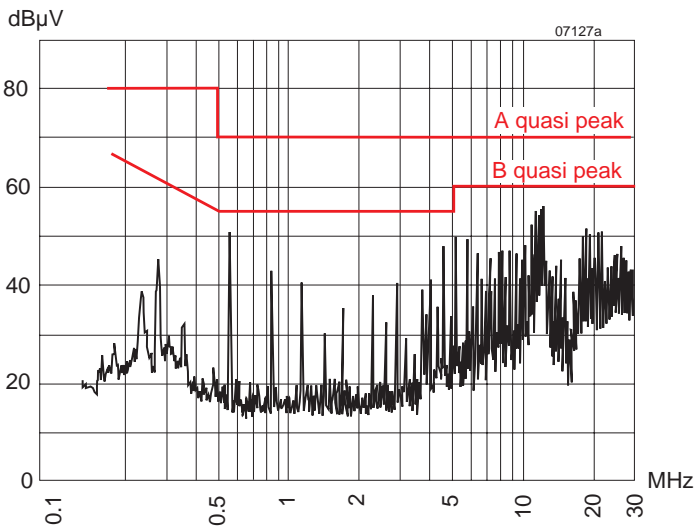


Fig. 20
CP 1001-7RB1
Typical disturbance voltage at the input ($V_{i\text{ nom}}$, $I_{i\text{ nom}}$, resistive load, quasi peak).

Immunity to Environmental Conditions

Table 10: 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 ^{±2} °C Relative humidity: 93 ^{+2/-3} % Duration: 56 days	Converter not operating
Kb	Salt mist, cyclic (sodium chloride NaCl solution)	IEC/EN 60068-2-52	Concentration: 5% (30°C) for 2 h Storage: 40°C, 93% rel. humidity for 22 h Number of cycles: 3 (= 3 days)	Converter not operating
Eb	Bump (half-sinusoidal)	IEC/EN 60068-2-29 MIL-STD-810D section 516.3	Acceleration amplitude: 25 g _n = 245 m/s ² Bump duration: 11 ms Number of bumps: 6000 (1000 in each direction)	Converter operating
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) Frequency (1 Oct/min): 10 – 2000 Hz Test duration: 7.5 h (2.5 h in each axis)	Converter operating
Ea	Shock (half-sinusoidal)	IEC/EN 60068-2-27 MIL-STD-810D section 516.3	Acceleration amplitude: 50 g _n = 490 m/s ² Bump duration: 11 ms Number of bumps: 18 (3 in each direction)	Converter operating
--	Shock	EN 50155 / EN 61373 sect. 10, class A and B body mounted ¹	Acceleration amplitude: 5.1 g _n Bump duration: 30 ms Number of bumps: 18 (3 in each direction)	Converter operating
Fda	Random vibration wide band Reproducibility high	IEC/EN 60068-2-35 DIN 40046 part 23	Acceleration spectral density: 0.05 g _n ² /Hz Frequency band: 20 – 500 Hz Acceleration magnitude: 4.9 g _{n,rms} Test duration: 3 h (1 h in each axis)	Converter operating
--	Simulated long life testing at increased random vibration levels	EN 50155 / EN 61373 sect. 9, cat 1, class B, body mounted ¹	Acceleration spectral density: 0.02 g _n ² /Hz Frequency band: 5 – 150 Hz Acceleration magnitude: 0.8 g _{n,rms} Test duration: 15 h (5 h in each axis)	Converter operating

¹ Body mounted = chassis of a railway coach

Temperatures

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

Temperature			-7 (option)			-9 (standard)			Unit
Characteristics	Conditions		min	typ	max	min	typ	max	
T _A	Ambient temperature	Converter operating ¹	-25		71	-40		71	°C
T _C	Case temperature ²		-25		95 ¹	-40		95 ¹	
T _S	Storage temperature	Non operational	-40		100	-55		100	
R _{th C-A}	Thermal resistance case to ambient in still air		2			2			K/W

¹ Operation with P_{o max} requires reduction to T_{A max} = 50 °C, T_{C max} = 85° C respectively; see *Thermal Considerations*.

² Overtemperature shut-down at T_C >95 °C (PTC)

Reliability

Table 12: MTBF and device hours

Ratings at specified	Model	Ground benign 40 °C	Ground fixed		Ground mobile 50 °C	Device hours ¹
Case Temperature		40 °C	40 °C	70 °C		
MTBF acc. to MIL-HDBK-217F, notice 2	CP 3000	340 000 h	88 000 h	42 000 h	40 000 h	7 670 000

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

Mechanical Data

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

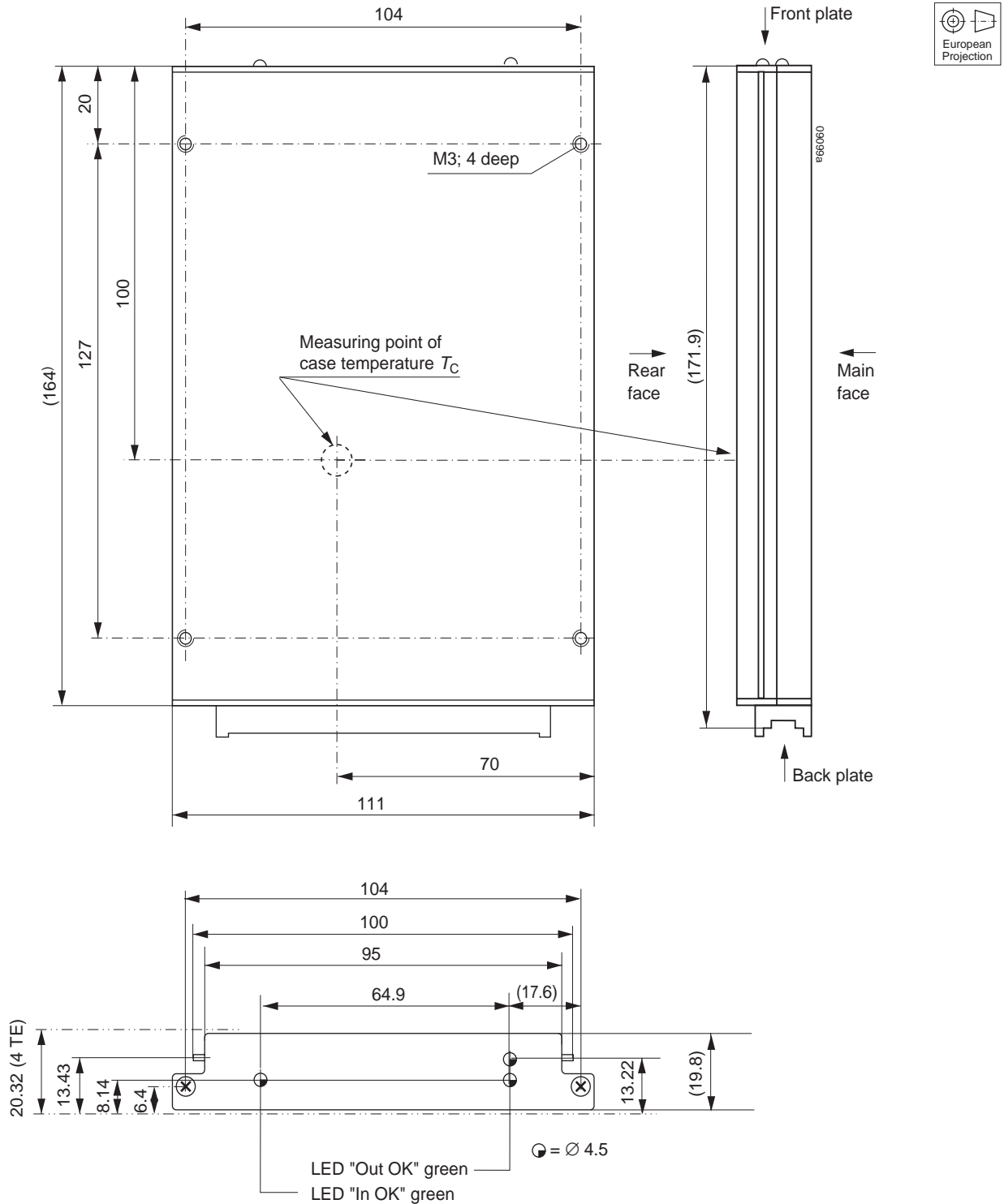


Fig. 21
Case Q04, weight app. 500 g
Aluminium, fully enclosed,
black finish and self cooling

Note: Long case, elongated by 60 mm for 220 mm rack depth is available on request.

Safety and Installation Instructions

Connector Pin Allocation

The connector pin allocation table defines the electrical potentials and the physical pin positions on the H15 and H15S2 connector. Pin no. 26, protective earth, is a leading pin to ensure that it makes contact with the female connector first.

Notes: The current through each standard H15 contact depends on the female connector, the ambient temperature, and the air flow in the region of the connector. We recommend to limit the mean current to 15 A at 50 °C and to 13 A at 71 °C.

High currents require a large cross-sectional area of the connections to the female contacts. We recommend solder or screw terminal contacts. Each faston connection exhibits a resistance of max. 8 mΩ, which makes it less suitable for high currents.

For single-output models with option K, always both output contacts must be used and connected in parallel to the load with large cross-sectional area wires or thick copper lands.

High-current contacts of P1000 models exhibit no restriction of the output current. Their resistance is only 1 mΩ.

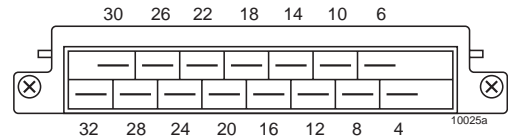


Fig. 22
View of male standard H15 connector

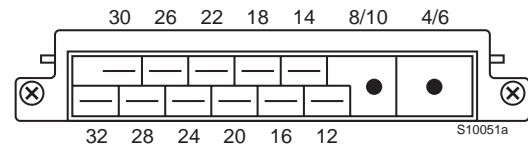


Fig. 23
View of male H15S2 connector (with high-current contacts) used in P1000 and P1100 without option K

Table 13: Pin allocation

Pin	P 1000		P2000		P3000		P4000	
4 ¹	Vo+	Output 1 pos.	Vo1+	Output 1 pos.	Vo1+	Output 1 pos.	Vo1+	Output 1 pos.
6 ¹	Vo+	Output 1 pos.	Vo2+	Output 2 pos.	Vo2+	Output 2 pos.	Vo2+	Output 2 pos.
8 ²	Vo-	Output 1 neg.	Vo1-	Output 1 neg.	Vo1-	Output 1 neg.	Vo1-	Output 1 neg. ⁶
10 ²	Vo-	Output 1 neg.	Vo2-	Output 2 neg.	Vo2-	Output 2 neg.	Vo2-	Output 2 neg.
12	S+	Sense +	S1+	Sense 1 +	S1+	Sense 1 +	Vo4+	Output 4 pos.
14	S-	Sense -	S1-	Sense 1 -	S1-	Sense 1 -	Vo4-	Output 4 neg. ⁶
16	R	Adjust of V_o	R1	Adjust of V_{o1}	R1	Adjust of V_{o1}	R1	Adjust of $V_{o1/4}$
			T1	Current share ³	T1	Current share ³		
18	T ⁷	Current share	S2+	Sense 2 +	Vo3+	Output 3 pos.	Vo3+	Output 3 pos.
20	n.c.	Not connected	S2-	Sense 2 -	Vo3-	Output 3 neg.	Vo3-	Output 3 neg.
22	n.c.	Not connected	n.c.	Not connected	n.c.	Not connected	n.c.	Not connected
	Out OK+	Out OK+ ⁴	Out OK+	Out OK+ ⁴	Out OK+	Out OK+ ⁴	Out OK+	Out OK+ ⁴
	i+	Inhibit second. ⁵	i+	Inhibit second. ⁵	i+	Inhibit second. ⁵	i+	Inhibit second. ⁵
24	n. c.	Not connected	n.c.	Not connected	n.c.	Not connected	n.c.	Not connected
	Out OK-	Out OK- ⁴	Out OK-	Out OK- ⁴	Out OK-	Out OK- ⁴	Out OK-	Out OK- ⁴
	i-	Inhibit second. ⁵	i-	Inhibit second. ⁵	i-	Inhibit second. ⁵	i-	Inhibit second. ⁵
26	⊕	Prot. earth PE	⊕	Prot. earth PE	⊕	Prot. earth PE	⊕	Prot. earth PE
28	i	Inhibit primary	i	Inhibit primary	i	Inhibit primary	i	Inhibit primary
30	Vi+	Input pos.	Vi+	Input pos.	Vi+	Input pos.	Vi+	Input pos.
32	Vi-	Input neg.	Vi-	Input neg.	Vi-	Input neg.	Vi-	Input neg.

¹ Pin 4/6 (high-current contact) for P1000 models with 3.3 V or 5.1 V output (H15S2 connector)

² Pin 8/10 (high-current contact) for P1000 models with 3.3 V or 5.1 V output (H15S2 connector)

³ Option T1 for 3.3 V and 5.1 V powertrains: Only I_{o1} is influenced

⁴ Option D

⁵ Option i

⁶ Powertrains with 5.1 V and 3.3 V outputs have a common return: Vo1- and Vo4- are connected together.

⁷ Not connected, if option T is not fitted.

Installation Instructions

These converters are components, intended exclusively for inclusion within other equipment by an industrial assembly process or by a professionally competent person. Installation must strictly follow the national safety regulations in respect of the enclosure, mounting, creepage distances, clearance, casualty, markings and segregation requirements of the end-use application.

Connection to the system shall be made via the female connector H15 or H15S2 (see *Accessories*). Other installation methods may not meet the safety requirements. Check for hazardous voltages before altering any connections. Pin 26 (PE) is a leading pin and is reliably connected to the case. For safety reasons it is essential to connect this pin to the protective earth of the supply system.

The Vi- input (pin 32) is internally fused. This fuse is designed to protect the converter against overcurrent caused by a failure, but may not be able to satisfy all requirements. External fuses in the wiring to one or both input pins (no. 30 and/or no. 32) may therefore be necessary to ensure compliance with local requirements.

Important: Whenever the inhibit function is not in use, pin 28 (i) should be connected to pin 32 (Vi-) to enable the output(s).

Do not open the converters, or the warranty will be invalidated. Make sure that there is sufficient airflow available for convection cooling. This should be verified by measuring the case temperature at the specified measuring point, when the converter is operated in the end-use application. $T_{C\ max}$ should not be exceeded. Ensure that a failure of the converter does not result in a hazardous condition; see also *Safety of Operator-Accessible Output Circuits*.

Standards and Approvals

The P Series converters are approved according to the safety standards IEC 60950-1, EN 60950-1, UL 60950-1, and CSA 60950-1.

They have been evaluated for:

- Class I equipment
- Building in
- Double or reinforced insulation based on 250 VAC or 240 VDC between input and output and between input and auxiliary circuits

Table 14: Isolation

Characteristic		Input to case + outputs ¹	Outputs to case	Output to output ⁴	Auxiliaries ³ to input	Auxiliaries ³ to case	Auxiliaries ³ to outputs	Unit
Electric strength test	Factory test >1 s	2.1 ¹	1.0	0.5	2.1 ¹	1.0	0.5	kVDC
	AC test voltage equivalent to actual factory test	1.5	0.7	0.35	1.5	0.7	0.35	kVAC
Insulation resistance		>300 ²	>300 ²	>100	>300 ²	>100	>100	MΩ

¹ In accordance with EN 50116, IEC/EN 60950, subassemblies are pre-tested with 4.2 kVDC.

² Tested at 500 VDC

³ Insulated secondary-referenced auxiliary circuits, i.e., Out OK circuit (option D), secondary inhibit input (option i).

⁴ Powertrain with 5.1 and 3.3 V output have a common return.

- Overvoltage category II
- Functional insulation between output(s) and case
- Functional insulation between the outputs
- Pollution degree 2 environment
- The converters fulfill the requirements of a fire enclosure.

CB-scheme is available (CB 06 07 24238 800).

The converters are subject to manufacturing surveillance in accordance with the above mentioned UL standards and with ISO 9001:2000.

Cleaning Agents

The converters are not hermetically sealed. In order to avoid possible damage, any penetration of liquids shall be avoided.

Protection Degree

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

Railway Application

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

Isolation

The electric strength test is performed in the factory as routine test in accordance with 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.

Safety of Operator-Accessible Output Circuits

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

The following table shows some possible installation configurations, compliance with which causes the output circuit of the DC-DC converter to be an SELV circuit according to IEC/EN 60950 up to a configured output voltage

(sum of nominal voltages if in series or +/- configuration) of 35 V.

However, it is the sole responsibility of the installer to ensure the compliance with the relevant and applicable safety regulations.

Use fuses and earth connections as per table below. See also *Installation Instructions*.

Table 15: Safety concept leading to an SELV output circuit

Conditions	Front end			DC-DC converter	Result
Nominal supply voltage	Minimum required grade of insulation, to be provided by the AC-DC front end, including mains supplied battery charger	Maximum DC output voltage from the front end ¹	Minimum required safety status of the front end output circuit	Measures to achieve the specified safety status of the output circuit	Safety status of the DC-DC converter output circuit
Mains ≤250 VAC	Functional (i.e. there is no need for electrical isolation between the mains supply circuit and the DC-DC converter input circuit)	≤168 V	Primary circuit (The nominal voltage between any input pin and earth shall not exceed 250 VAC or 240 VDC.)	Double or reinforced insulation, based on 250 VAC and 240 VDC (provided by the DC-DC converter) and earthed case ²	SELV circuit
	Basic		Earth related hazardous voltage secondary circuit (The nominal voltage between any input pin and earth shall not exceed 250 VAC or 240 VDC.)	Double or reinforced insulation, based on the maximum nominal output voltage from the front end (both provided by the DC-DC converter) and earthed case ²	
			Unearthed hazardous voltage secondary circuit	Supplementary insulation, based on 250 VAC and DC and double or reinforced insulation, based on the maximum nominal output voltage from the front end (both provided by the DC-DC converter) and earthed case ²	
Supplementary			Unearthed hazardous voltage secondary circuit ³	Basic insulation, based on 250 VAC and DC (provided by the DC-DC converter)	

¹ The front end output voltage should match the specified input voltage range of the DC-DC converter. The maximum rated input voltage of EP types is 150 V according to IEC/EN 60950.

² The earth connection has to be provided by the installer according to the relevant safety standards, e.g., IEC/EN 60950.

³ Has to be insulated from earth by at least supplementary insulation (by the installer) according to the relevant safety standards, e.g. IEC/EN 60950, based on the maximum nominal output voltage from the front end. If the converter case is accessible, it has to be earthed or the front end output circuit has to be insulated from the converter case by at least basic insulation, based on the maximum nominal mains supply voltage.

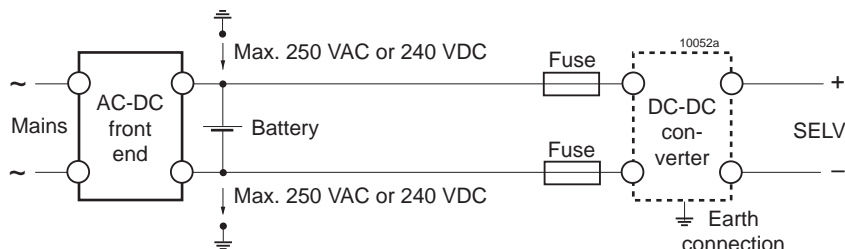


Fig. 24
Schematic safety concept

Description of Options

Option D: Out OK Monitor

Option D monitors the state of the output error amplifiers on both power trains and not the input voltage, output voltage or the current limit. It signals a fault, when one of the error amplifiers reaches its limit, which means that at least one output voltage is not within its regulation limits. This could be because the input voltage is below the minimum level or the load current is too high. This function is not adjustable.

A galvanically isolated open-collector output generates the "Out OK" signal. The circuit monitors simultaneously if

- the input voltage is present - same logic as LED "In OK"
- the output voltages are within their limits - same logic as LED(s) "Out OK".

The open collector is conducting, if the monitored conditions are fulfilled.

This option is located on a subassembly allowing special circuit design on customer request.

Table 16: Output OK data

Characteristics / Conditions		min	typ	max	Unit
V_{OK}	Out OK voltage Output good, $I_{OK} < 50$ mA	0.8	1.5		V
I_{OK}	Out OK current Output out of range, $V_{OK} < 18$ V		25		μ A

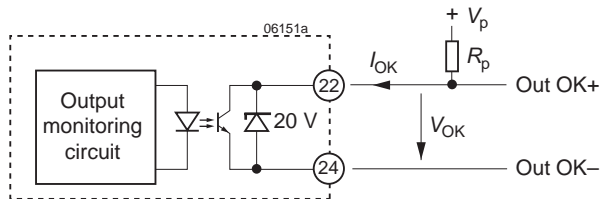


Fig. 25
Output OK circuit (option D)

Dimensioning of resistor value $R_p \geq \frac{V_p}{50 \text{ mA}}$

Caution: The Out OK circuit is protected by a Zener diode. To prevent damage, the applied current I_{OK} should be limited to ± 50 mA. The Zener diode should not be exposed to more than 0.25 W.

Option T: Active Current Sharing

For 3.3 V and 5.1 V outputs only. The current share facility should be used, where several converters are operated in parallel. Examples could be high reliability n+1 redundant systems or systems providing higher output power.

Using this feature reduces the stress of individual converters and improves the reliability of the system. Interconnection of the current sharing pins T or T1 causes the converters to share their output current evenly.

In redundant systems, the outputs of the converters are

decoupled by ORing diodes. Consequently, a failure of one converter will not lead to a system failure.

Since the voltage on the T or T1 pin is referenced to the sense pin S-, the installer must ensure that the S- pins of all parallel converters are at the same electrical potential and that there are no voltage drops across the connection lines between these pins.

BP – GP2000 converters with outputs connected in series can also be paralleled with current sharing, if pins Vo1- of all converters are connected together; see *Sense Lines*. If the output voltages are programmed to a voltage other than $V_{o, nom}$ by means of the R pin, the outputs should be adjusted individually within a tolerance of $\pm 1\%$.

Note: Option T is only available for 3.3 V or 5.1 V single-output power trains and only for output 1. In dual- or triple-output models, option T1 influences only output 1. In addition, the second power train has no R input (since no pin is left for that function).

Option i: Secondary-Referenced Inhibit

The inhibit function is located on the primary side. Option i gives the possibility of an inhibit function on the secondary side using two galvanically isolated pins i+ and i-. The power supply may be inhibited from either the input or the output inhibit logic. The inhibit is enabled or disabled by a logic signal (TTL, CMOS, etc). Output enabled: Logic low (<0.8 V) Output inhibited: Logic high (>2.4 V).

This option excludes Opt.-D.

Opt.-i is located on a subassembly allowing special circuit design on customer request.

The secondary inhibit is fully floating with operational insulation to the secondary circuits (which is not sufficient to be used as a primary to secondary insulation).

The input is CMOS compatible, and the level should not exceed 5V. The internal pull-up (to an internal 5 V supply) is 10 kOhms. We suggest connecting i- to Sense-; otherwise the inhibit potential will be undefined.

Option B1 and B3: Heat Sink

The converter is fitted with an additional heat sink.

Table 17: Thermal resistance case to ambient (approx. values)

Option	Thermal resistance	Thickness of case
Standard, 160 mm long	1.6 K/W	< 20 mm
Housing, 220mm long ¹	1.4 K/W	< 20 mm
Option B1	1.4 K/W	< 40 mm
Option B3	1.2 K/W	< 50 mm

¹ Customer-specific models

Option G

RoHS compliant for all six substances.

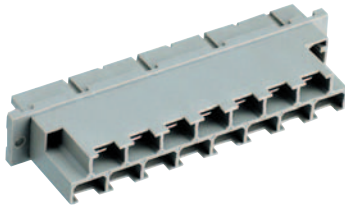
Accessories

A great variety of electrical and mechanical accessories are available:

- Additional external input or output filters
- Mating connectors including fast-on, screw, solder, or press-fit terminals
- Cable connector housing
- Front panels for 19" rack in 3U or 6U configuration

- Mechanical mounting supports for chassis, DIN-rail, and PCB mounting
- Connector retention facilities

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 female connector, code key system



Universal mounting bracket for DIN-rail and chassis mounting



Front panel for 19" rack with 6U

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.

EC Declaration of Conformity

CE MARKING

We, **Power-One, Inc., 740 Calle Plano, Camarillo, CA. 93012 USA**
declare under our sole responsibility that the products;

Power Supply Model: P Series

to which this declaration relates, is/are in compliance with the following document(s):

Quality Standard(s): **ISO 9001, EN 29001**

Directive: **DIR 73/23/EEC, Low Voltage Directive**

Product Safety Standard(s): **EN 60950-1: 2001**
IEC 60950-1: 2001
(Licensed by a Notified Body to the European Union)

These component level power supplies are intended exclusively for inclusion within other equipment by an industrial assembly operation or by professional installers per the Installation Instructions provided with the power supplies. The power supplies are considered Class I and must be connected to a reliable earth grounding system.



(Manufacturer)

Robert P. White Jr.
Product Safety Director

Camarillo, Ca.

(Place)

July 5, 2006

(Date)