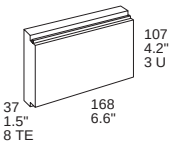
power-one™
Changing the Shape of Power



Input voltage up to 60 VDC
Single output of 12 - 24 VDC
No input to output isolation

- High efficiency up to 93%
- Wide input voltage range
- Low input-to-output differential voltage
- Very good dynamic properties
- Input undervoltage lock-out
- Parallel configurations possible
- Continuous no-load and short-circuit proof
- No derating

Safety according to IEC/EN 60950

c UL us CE

Summary

The PSL series of positive switching regulators is designed as power supply modules for electronic systems. Their major advantages include a high level of efficiency that remains virtually constant over the entire input range, high reliability, low ripple and excellent dynamic response. Modules with input voltages up to 60 V are specially designed for secondary switched and battery driven applications. The case design allows operation at nominal load up to 50℃ without additional cooling.

The modules are fitted with an H11 connector and may either be plugged into 19" rack systems according to IEC 60297-3, or be chassis mounted.

Model Selection and Key Data

Table 1: Type survey

Output voltage $V_{o\,nom}$ [V]	Output current $I_{o\,nom}$ [A]	Input voltage range V_i [V] [1]	Input voltage $V_{i\,nom}$ [V]	Efficiency [2] η_{min} [%]	Type designation
5.1	11	8 - 40	20	78	PSL 5A11-2R
12	9	15 - 40	20	89	PSL 129-2R
15	9	19 - 40	30	90	PSL 159-2R
24	9	29 - 60	40	93	PSL 249-2R

[1] See also: *Electrical Input Data:* $\Delta V_{io\,min}$. (min. difference V_i - V_o)
[2] Efficiency at $V_{i\,nom}$ and $I_{o\,nom}$.

Table of Contents

Part Number Description

Type Key

PSL 12 9 -2 R

Positive switching regulator in case L04 ..... PSL
Nominal output voltage in volt (5A for 5.1 V) ..... 5A - 24
Nominal output current in ampere ..... 9 - 11
Operational ambient temperature range T_A
–10 to 50°C ..... -2
Control input for output voltage adjustment ..... R

Example: PSL 129-2R = A positive switching regulator with a 12 V, 9 A output, ambient temperature range of –10 to 50°C, with control input for output voltage adjustment.

Product Marking

Series designation, applicable safety approvals and recognition marks, warnings, pin allocation, Power-One patent nos. and company logo.

Specific type designation, input voltage range, nominal output voltage and current, pin allocation of auxiliary function and protection degree.

Label with batch no., serial no. and data code comprising production site, modification status of the main PCB and date of production.

Functional Description

The switching regulators are designed using the buck converter topology. See also: *Technical Information: Topologies*. The input is not electrically isolated from the output. During the on period of the switching transistor, current is transferred to the output and energy is stored in the output choke. During the off period, this energy forces the current to continue flowing through the output, to the load and back through the freewheeling diode. Regulation is accomplished by varying the on to off duty ratio of the power switch.

These regulators are ideal for a wide range of applications, where input to output isolation is not necessary, or where already provided by an external front end (e.g. a transformer with rectifier). To optimise customer's needs, additional options and accessories are available.

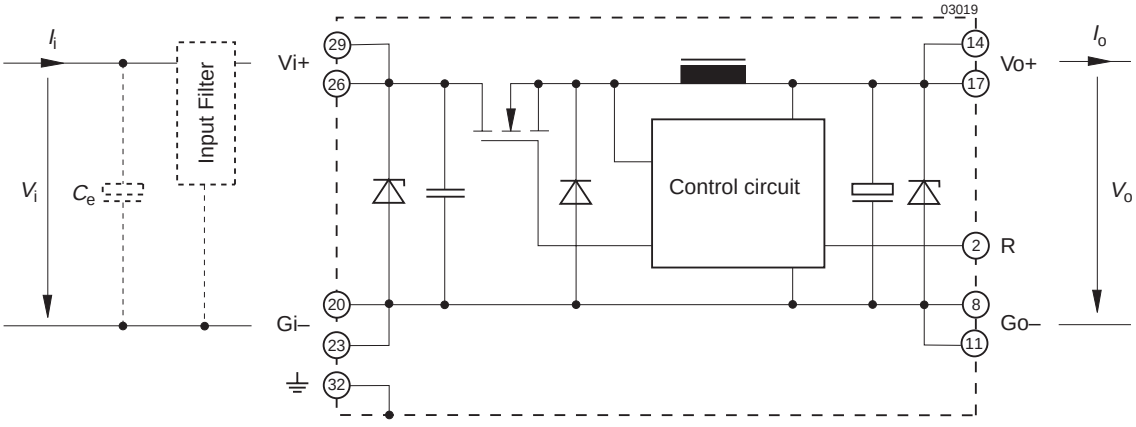


Fig. 1
Block diagram

Electrical Input Data

General Conditions: T_A = 25℃, unless T_C is specified

Table 2: Input data

Input			PSL 5A11			PSL 129			PSL 159			PSL 249			
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	Unit
V_i	Operating input voltage	I_o = 0 - $I_{o\,nom}$ $T_{C\,min}$ - $T_{C\,max}$	8		40	15		40	19		40	29		60	VDC
$\Delta V_{io\,min}$	Min. diff. voltage V_i – V_o				2.9			3			4			5	
$V_{i\,o}$	Undervoltage lock-out			7.3			7.3			7.3			12		
$I_{i\,0}$	No load input current	I_o = 0, $V_{i\,min}$ - $V_{i\,max}$			50			50			50			50	mA
$I_{inr\,p}$	Peak value of inrush current	$V_{i\,nom}$		75			75			250			250		A
$t_{inr\,r}$	Rise time			5			5			5			5		µs
$t_{inr\,h}$	Time to half-value			40			40			40			40		
$u_{i\,RFI}$	Input RFI level, EN 55011/22 0.15 - 30 MHz [1]	$V_{i\,nom}$, $I_{o\,nom}$			A			A			A			A	dB (µV)

[1] Additional external input filter or capacitor necessary.

External Input Circuitry

The sum of the lengths of the supply lines to the source or to the nearest capacitor ≥100 µF (a + b) should not exceed 5 m unless an external input filter with capacitor is fitted. This filter is recommended in order to prevent power line oscillations and reduce superimposed interference voltages. See also *Technical Information*: *Application Notes*.

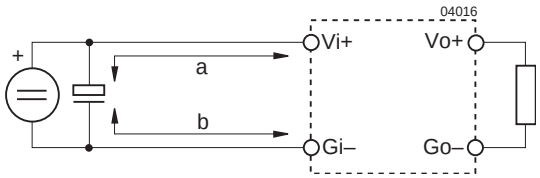


Fig. 2
Switching regulator with long supply lines.

Electrical Output Data

General Conditions:
– T_A = 25℃, unless T_C is specified
– With R control output voltage V_o = $V_{o\,nom}$ at $I_{o\,nom}$

Table 3: Output data

Output				PSL 5A11			PSL 129			PSL 159			PSL 249			
Characteristics			Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	Unit
V_o	Output voltage		$V_{i\,nom}$, $I_{o\,nom}$	5.05		5.15	11.60		12.40	14.50		15.50	23.30		24.70	V
I_o	Output current [1]		$V_{i\,min}$ - $V_{i\,max}$ $T_{C\,min}$ - $T_{C\,max}$	0		11.0	0		9.0	0		9.0	0		9.0	A
I_{oL}	Output current limitation response			11.0		14.3	9.0		11.7	9.0		11.7	9.0		11.7	
u_o	Output voltage noise	Switching freq.	$V_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 [2] BW = 20 MHz			55			150			200			300	mV_{pp}
		Total				60			160			210			310	
$\Delta V_{o\,U}$	Static line regulation		$V_{i\,min}$ - $V_{i\,max}$, $I_{o\,nom}$			100			240			300			480	mV
$\Delta V_{o\,I}$	Static load regulation		$V_{i\,nom}$, I_o = 0 - $I_{o\,nom}$			100			120			150			240	
$u_{o\,d}$	Dynamic load regulation	Voltage deviat.	$V_{i\,nom}$ $I_{o\,nom} \leftrightarrow {}^1/_3\ I_{o\,nom}$ IEC/EN 61204 [2]	150			360			450			700			
t_d		Recovery time		50			60			60			80			µs
α_{Uo}	Temperature coefficient $\Delta V_o/\Delta T_C$ ($T_{C\,min}$ - $T_{C\,max}$)		$V_{i\,min}$ - $V_{i\,max}$ I_o = 0 - $I_{o\,nom}$			±1			±2			±3			±5	mV/K
						±0.02			±0.02			±0.02			±0.02	%/K

[1] See also: *Thermal Considerations.*
[2] See: *Technical Information: Measuring and Testing.*

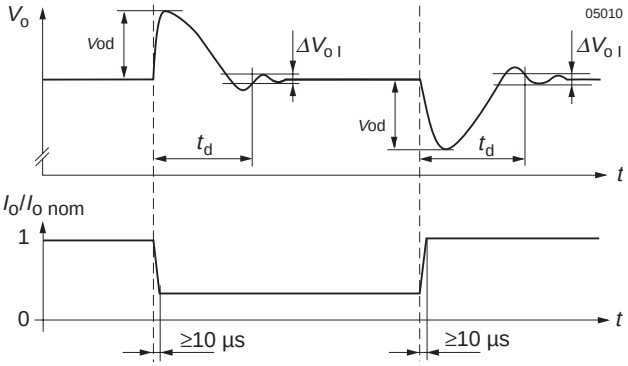


Fig. 3
Dynamic load regulation.

Thermal Considerations

When a switching regulator is located in free, quasi-stationary air (convection cooling) at a temperature T_A = 50℃ and is operated at its nominal output current $I_{o\,nom}$, the case temperature T_C will be about 80℃ after the warm-up phase, measured at the *Measuring point of case temperature* T_C (see: *Mechanical Data*).

Under practical operating conditions, the ambient temperature T_A may exceed 50℃, provided additional measures (heat sink, fan, etc.) are taken to ensure that the case temperature T_C does not exceed its maximum value of 80℃.

Example: Sufficient forced cooling allows $T_{A\,max}$ = 65℃. A simple check of the case temperature T_C (T_C ≤80℃) at full load ensures correct operation of the system.

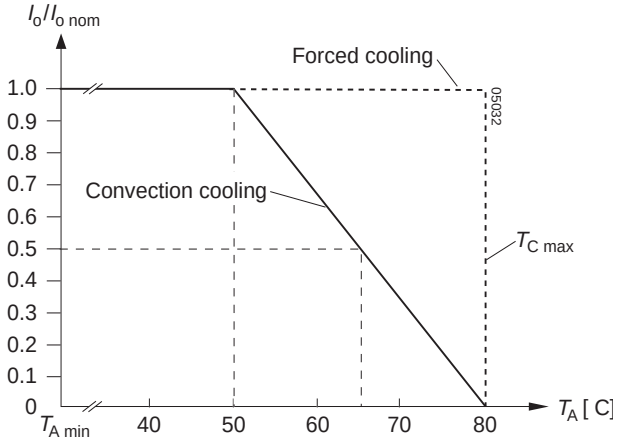


Fig. 4
Output current derating versus temperature.

Output Protection

A voltage suppressor diode which in worst case conditions fails into a short circuit, protects the output against an internally generated overvoltage. Such an overvoltage could occur due to a failure of either the control circuit or the switching transistor. The output protection is not designed to withstand externally applied overvoltages. The user should ensure that systems with Power-One power supplies, in the event of a failure, do not result in an unsafe condition (fail-safe).

Parallel and Series Connection

Outputs of equal nominal voltages can be parallel-connected. However, the use of a single unit with higher output power, because of its power dissipation, is always a better solution.

In parallel-connected operation, one or several outputs may operate continuously at their current limit knee-point which will cause an increase of the heat generation. Consequently, the max. ambient temperature value should be reduced by 10 K.

Outputs can be series-connected with any other module. In series-connection the maximum output current is limited by the lowest current limitation. Electrically separated source voltages are needed for each module!

Short Circuit Behaviour

A constant current limitation circuit holds the output current almost constant whenever an overload or a short circuit is applied to the regulator's output. It acts self-protecting and recovers – in contrary to the fold back method – automatically after removal of the overload or short circuit condition.

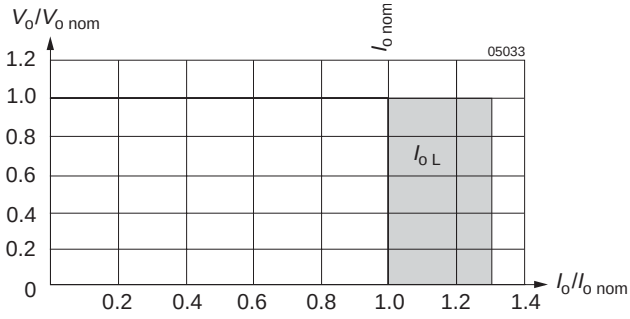


Fig. 5
Overload, short-circuit behaviour V_o versus I_o.

Auxiliary Functions

R Control for Output Voltage Adjustment

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

The output voltage V_o can either be adjusted with an external reference voltage (V_{ext}) or with an external resistor (R_{ext}). The adjustment range is 0 - 100% of $V_{o\,nom}$. The minimum differential voltage Ð$V_{io\,min}$ between input and output (see *Electrical Input Data*) should be maintained. Undervoltage look-out = minimum input voltage.

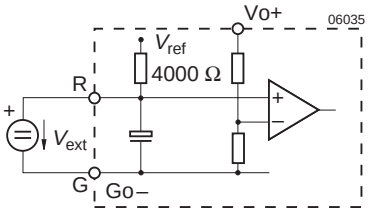


Fig. 6
Voltage adjustment with V_{ext} between R and Go–

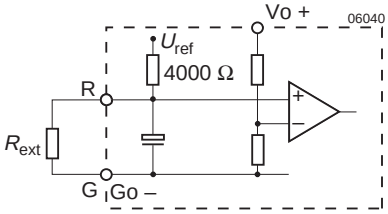


Fig. 7
Voltage adjustment with external resistor R_{ext}

$$V_{ext} \approx 2.5\ V \bullet \frac{V_o}{V_{o\,nom}} \qquad V_o \approx V_{o\,nom} \bullet \frac{V_{ext}}{2.5\ V}$$

$$R_{ext} \approx \frac{4000\ \Omega \bullet V_o}{V_{o\,nom} - V_o} \qquad V_o \approx \frac{V_{o\,nom} \bullet R_{ext}}{R_{ext} + 4000\ \Omega}$$

Caution: To prevent damage V_{ext} must neither exceed 2.7 V, nor be negative!

Electromagnetic Compatibility (EMC)

Electromagnetic Immunity

General condition: Case not earthed.

Table 4: Immunity type tests

Phenomenon	Standard [1]	Class Level	Coupling mode [2]	Value applied	Waveform	Source Imped.	Test procedure	In oper.	Perform. [3]
Electrostatic discharge	IEC/EN 61000-4-2	2	contact discharge to case	4000 V_p	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	A [4]
Electromagnetic field	IEC/EN 61000-4-3	2	antenna	3 V/m	AM 80% 1 kHz		80 - 1000 MHz	yes	A
Electrical fast transients/burst	IEC/EN 61000-4-4	2	i/c, +i/–i	1000 V_p	bursts of 5/50 ns 5 kHz rep. rate transients with 15 ms burst duration and a 300 ms period	50 Ω	60s positive 60s negative bursts per coupling mode	yes	A [4]
		3		2000 V_p					B [4]
Surge	IEC/EN 61000-4-5	2	i/c	1000 V_p	1.2/50 µs	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	A [4]
			+i/–i	500 V_p		2 Ω			
Conducted disturbances	IEC/EN 61000-4-6	2	i, o, signal wires	130 dBµV (3 VAC)	AM 80% 1 kHz	150 Ω	0.15 - 80 MHz	yes	A

[1] For related and previous standards see: *Technical Information: EMC*.
[2] i = input, o = output, c = case.
[3] A = Normal operation, no deviation from specifications, B = Normal operation, temporary deviation from specs possible.
[4] External input filter neccessary.

For emission levels refer to: *Electrical Input Data.*

Immunity to Environmental Conditions

Table 5: Mechanical stress

Test Method		Standard	Test Conditions		Status
Ca	Damp heat steady state	IEC/DIN 60068-2-3 MIL-STD-810D, section 507.2	Temperature: Relative humidity: Duration:	40 $^{\pm 2}$ ℃ 93 $^{+2/-3}$ % 21 days	Unit not operating
Ea	Shock (half-sinusoidal)	IEC/EN/DIN 60068-2-27 MIL-STD-810D, section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	15 g_n = 147 m/s^2 11 ms 18 (3 each direction)	Unit operating
Eb	Bump (half-sinusoidal)	IEC/EN/DIN 60068-2-29 MIL-STD-810D, section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	10 g_n = 392 m/s^2 16 ms 6000 (1000 each direction)	Unit operating
Fc	Vibration (sinusoidal)	IEC/EN/DIN 60068-2-6 MIL-STD-810D, section 514.3	Acceleration amplitude: Frequency range (1 Oct/min): Test duration:	0.15 mm (10 - 60 Hz) 2 g_n = 20 m/s^2 (60 - 150 Hz) 10 - 150 Hz 3.75 h (1.25 h each axis)	Unit operating

Table 6: Temperature specifications, valid for an air pressure of 800 - 1200 hPa (800 - 1200 mbar)

Temperature			Standard		
Characteristics		Conditions	min	max	Unit
T_A	Ambient temperature	Operational [1]	–10	50	℃
T_C	Case temperature		–10	80	
T_S	Storage temperature	Non operational	–25	100	

[1] See: *Thermal Considerations*

Table 7: MTBF

MTBF	Ground Benign
MTBF acc. to MIL-HDBK-217F	T_C = 40℃
	484'000 h

Mechanical Data

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

European Projection

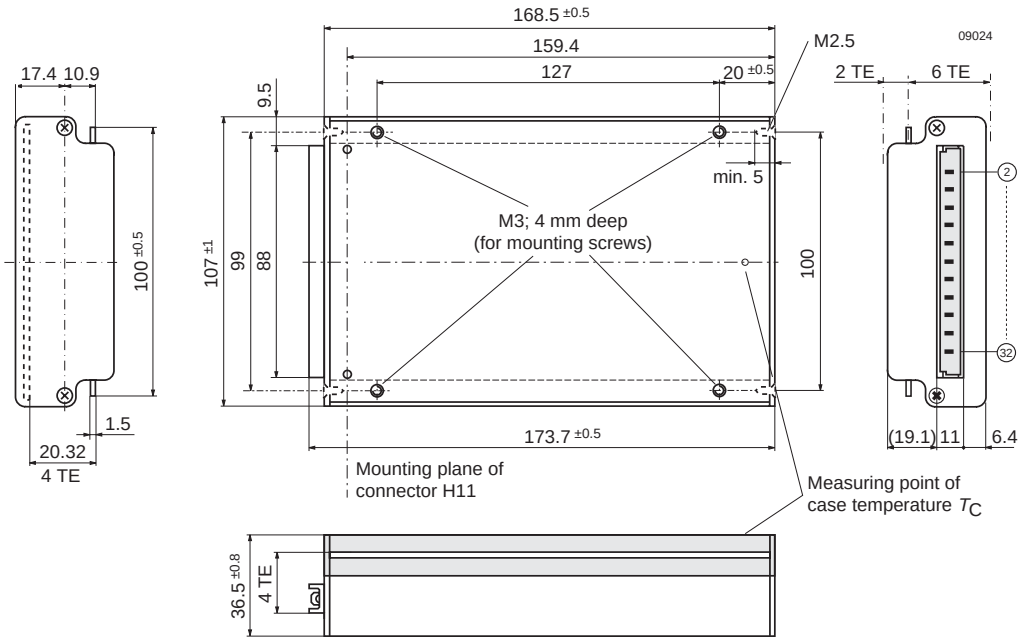


Fig. 8
Case L04, weight 550 g
Aluminium, black finish and self cooling

Safety and Installation Instructions

Connector Pin Allocation

The connector pin allocation table defines the electrical potentials and the physical pin position on the connector. Pin no. 32 is the protective ground pin and is leading, i.e. attaching the female connector, this pin provides electrical contact first. The modules should only be wired via the female connector H11 (according to DIN 41612) to ensure requested safety!

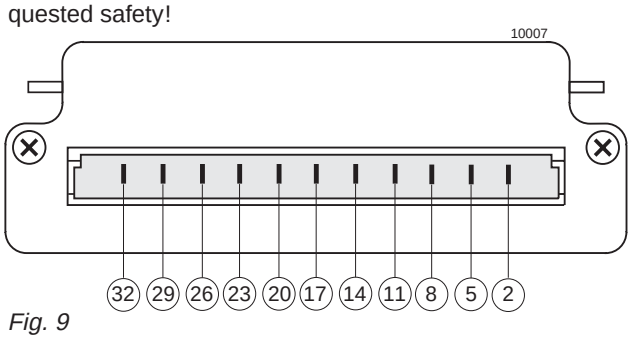


Fig. 9
View of male H11 connector

Installation Instruction

Installation of the switching regulators 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.

Check for hazardous voltages before altering any connections. Connections can be made using fast-on, screw or soldering technique, by means of female H11 connectors.

The input and the output circuit are not separated. i.e. the negative path is internally interconnected!

The units should be connected to a secondary circuit.

Do not open the modules.

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

Protection Degree

The protection degree is IP 20. It applies only if the module is plugged-in or the female connector is properly attached to the module.

Table 8: H11 connector pin allocation and designation

Electrical Determination	Type H11	
	Pin No.	Design.
R-input	2	R
Not connected	5	-
Output voltage (negative)	8	Go–
Output voltage (negative)	11	Go–
Output voltage(positive)	14	Vo+
Output voltage (positive)	17	Vo+
Input voltage (negative)	20	Gi–
Input voltage (negative)	23	Gi–
Input voltage (positive)	26	Vi+
Input voltage (positive)	29	Vi+
Protective ground (leading pin)	32	⏚

Standards and Approvals

All switching regulators are UL recognized according to UL 1950, UL recognized for Canada to CAN/CSA C22.2 No. 234-M90.

The units have been evaluated for:

- Building in
- Operational insulation from input/output to case
- The use in a pollution degree 2 environment
- Connecting the input to a secondary circuit which is subject to a maximum transient rating of 500 V

The switching regulators are subject to manufacturing surveillance in accordance with the above mentioned UL and CSA and with ISO 9001 standards.

Isolation

Electric strength test voltage between input interconnected with output against case: 500 VDC, 1 s.

This test is performed in the factory as routine test in accordance with EN50116, IEC/EN 60950 and UL 1950 and should not be repeated in the field. Power-One will not honour any guarantee claims resulting from electric strength field tests.

Safety of Operator Accessible Output Circuit

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

The following table shows some possible installation configurations, compliance with which causes the output circuit of the switching regulator to be an SELV circuit according to IEC/EN 60950 up to a configured nominal output voltage of 30 V.

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

More information is given in: *Technical Information: Safety*.

Table 9: Safety concept leading to an SELV output circuit

Conditions	Front end			Switching regulator	Result
Supply voltage	Minimum required grade of isolation, 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 switching regulator output circuit
Battery supply, considered as secondary circuit	Double or Reinforced	≤60 V	SELV circuit	None	SELV circuit
Mains ≤250 V AC	Basic	≤60 V	Earthed SELV circuit [2]	None	Earthed SELV circuit
			ELV circuit	Input fuse [3] and earthed output circuit [2] and earthed [2] or non user accessible case	
	Double or reinforced	≤60 V	SELV circuit	None	SELV circuit

[1] The front end output voltage should match the specified input voltage range of the switching regulator.
[2] The earth connection has to be provided by the installer according to the relevant safety standard, e.g. IEC/EN 60950.
[3] The installer shall provide an approved fuse (slow blow type with the lowest current rating suitable for the application, max. 12.5 A) in a non-earthed input conductor directly at the input of the switching regulator. If Vo+ is earthed, insert the fuse in the Gi- line. For UL's purpose, the fuse needs to be UL-listed. If option C is fitted, a suitable fuse is already built-in in the Vi+ line.

Accessories

A variety of electrical and mechanical accessories are available including:

– Front panels for 19" rack mounting, Schroff and Intermas systems.
– Mating H11 connectors with screw, solder, fast-on or press-fit terminals.

For more detailed information please refer to: *Accessory Products on the Power-One Homepage.*

power-one™
Changing the Shape of Power

EC Declaration of Conformity

We

Power-One AG
Ackerstrasse 56 CH-8610 Uster

declare under our sole responsibility that all PSx Series switching regulators carrying the CE-mark are in conformity with the provisions of the Low Voltage Directive (LVD) 73/23/EEC of the European Communities.

Conformity with the directive is presumed by conformity wih the following harmonized standards:

- EN 61204: 1995 (= IEC 61204: 1993, modified)
  Low-voltage power supply devices, d.c. output - Perfomance characteristics and safety requirements

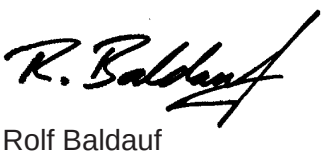
- EN 60950: 1992 + A1: 1993 + A2 (= IEC 950 second edition 1991 + A1: 1992 + A2: 1993)
  Safety of information technology equipment

The installation instructions given in the corresponding data sheet describe correct installation leading to the presumption of conformity of the end product with the LVD. All PSx Series Switching Regulators are components, intended exclusively for inclusion within other equipment by an industrial assembly operation or by professional installers. They must not be operated as stand alone products.

Hence conformity with the Electromagnetic Compatibility Directive 89/336/EEC (EMC Directive) needs not to be declared. Nevertheless, guidance is provided in most product application notes on how conformity of the end product with the indicated EMC standards under the responsibility of the installer can be achieved, from which conformity with the EMC directive can be presumed.

Uster, 14 Oct. 2003

Power-One AG



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