100 Watt AC-DC Converters with PFC

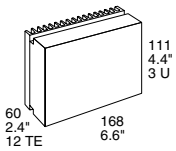
S Series

Input voltage range from 85...264 V AC
1 or 2 isolated outputs up to 48 V DC
4 kV AC I/O electric strength test voltage

- Universal input voltage range
- Power factor >0.95, harmonics <IEC/EN 61000-3-2
- Input over- and undervoltage lock-out
- Efficient input filter and built-in surge and transient suppression circuitry
- Fully isolated outputs
- Outputs overload, open- and short-circuit proof
- No derating over entire operating temperature range

Safety according to IEC/EN 60950





Summary

The S 4000/S 5000 series of AC-DC converters represents a flexible range of power supplies for use in advanced electronic systems. Features include full power factor correction, high efficiency, high reliability, low output voltage noise and excellent dynamic response to load/line changes.

The converter inputs are protected against surges and transients occurring at the source lines. An input over- and undervoltage lock-out circuitry disables the outputs if the input voltage is outside the specified range. Inrush current limitation is included preventing circuit breakers and fuses from being damaged at switch-on.

All outputs are overload, open- and short-circuit proof and are protected against overvoltages by means of a built-in suppressor diode. The outputs can be inhibited by a logic signal applied to the connector pin 18 (i). If the inhibit function is not used pin 18 must be connected to pin 14 to enable the outputs.

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

Full input to output, input to case, output to case and output to output isolation is provided. The modules are designed and built according to the international safety standards IEC/EN 60950 and have been approved by the safety agencies LGA (Germany) and UL (USA). The UL Mark for Canada has been officially recognized by regulatory authorities in provinces across Canada.

The case design allows operation at nominal load up to 71°C in a free air ambient temperature. If forced cooling is provided, the ambient temperature may exceed 71°C but the case temperature must remain below 95°C under all conditions.

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

Various options are available to adapt the converters to individual applications.

The modules may either be plugged into 19" rack systems according to DIN 41494, or be chassis mounted.

Important:
These products are intended to replace the LS 1000 and LS 2000 in order to comply with IEC/EN 61000-3-2.

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Type Survey and Key Data

Non standard input/output configuration or special custom adaptions are available on request. See also: *Commercial Information: Inquiry Form for Customized Power Supply.*

Table 1: Type survey LS

Output 1 $U_{o\,nom}$ [V DC]	Output 1 $I_{o\,nom}$ [A] [2]	Output 2 $U_{o\,nom}$ [V DC]	Output 2 $I_{o\,nom}$ [A] [2]	Input Voltage Range $U_{i\,min}...U_{i\,max}$ **85...255 V AC** [6]	Efficiency [1] η_{min} [%]	Options
5.1	16.0			LS 4001-7R	77	-9
12.0	8.0			LS 4301-7R	81	E
15.0	6.5			LS 4501-7R	83	D
24.0	4.2			LS 4601-7R	83	V [5]
24.0 [3]	4.0			LS 5320-7R	81	P
30.0 [3]	3.2			LS 5540-7R	81	T
48.0 [3]	2.0			LS 5660-7R	81	B1
12.0	4.0	12.0 [4]	4.0	LS 5320-7R	81	B2
15.0	3.2	15.0 [4]	3.2	LS 5540-7R	81	
24.0	2.0	24.0 [4]	2.0	LS 5660-7R	81	

[1] Efficiency at $U_{i\,nom}$ and $I_{o\,nom}$.
[2] If the output voltages are increased above $U_{o\,nom}$ via R-input control, option P setting, remote sensing or option T, the output currents must be reduced accordingly so that $P_{o\,nom}$ is not exceeded.
[3] Series connection of output 1 and 2, see: *R-Function for different output configurations*.
[4] Second output semi-regulated.
[5] Option V for LS 4000 types with 5 V outputs.
[6] For DC-input please ask your local Power-One partner.

Type Key

Type Key

L S 5 5 40 -7 E R P D V T B1

Input voltage range U_i: 85...255 V AC L
Series ..... S
Number of outputs (4 for single, 5 for double outputs) 4...5
Single output units:
Nominal voltage output 1 (main output), $U_{o1\,nom}$
5.1 V 0, 1, 2
12 V 3
15 V 4, 5
24 V 6
other voltages 7, 8
Other specifications for single output modules ..... 01...99
Symmetrical double output units:
Nominal voltage output 1/output 2, $U_{o1/2\,nom}$
12 V/12 V [1] (24 V series conn.) 20
15 V/15 V [1] (30 V series conn.) 40
24 V/24 V [1] (48 V series conn.) 60
other symmetrical voltages ..... 70...99
Operational ambient temperature range T_A:
–25...71 °C ..... -7
–40...71 °C ..... -9
customer specific ..... -0...-6
Auxiliary functions and options:
Inrush current limitation ..... E
Output voltage control input ..... R [2]
Potentiometer (output voltage adjustment) .. P [2]
Save data signal (D0...DD, to be specified) D [3]
ACFAIL signal (V2, V3) ..... V [3, 4]
Current sharing ..... T
Cooling plate standard case B1
Cooling plate for longe case 220 mm B2

[1] External wiring of main and second output depending upon the desired output configuration (see: *R-Function for different output configurations).*
[2] Feature R excludes option P and vice versa.
[3] Option D excludes option V and vice versa.
[4] Option V available for LS 4000 types with 5V output.

Functional Description

The input voltage is fed via an input fuse, an input filter, a rectifier and an inrush current limiter to a single transistor boost converter. This converter provides a sinusoidal input current (IEC/EN 61000-3-2, class D equipment) and sources a capacitor with a voltage of 360-370 V DC. This capacitor sources a single transistor forward converter.

Each output is powered by a separate secondary winding of the main transformer. The resultant voltages are rectified and their ripples smoothed by a power choke and an output filter. The control logic senses the main output voltage U_{o1} and generates, with respect to the maximum admissible output currents, the control signal for the primary switching transistor.

The second output of double output units is controlled by the main output, but has independent current limiting. If the main output is driven into current limitation, the second output voltage will fall as well and vice versa.

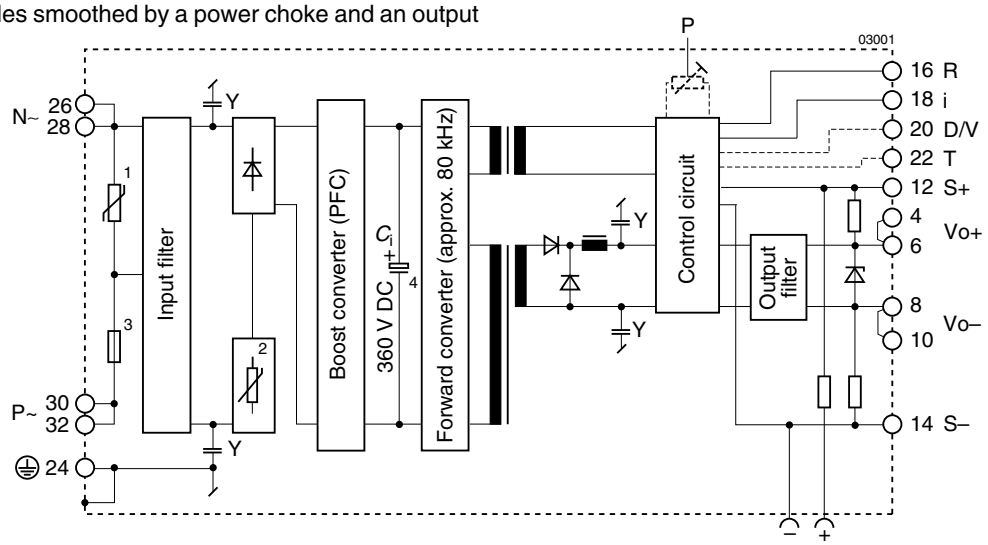


Fig. 1
Block diagram of single output converters LS 4000

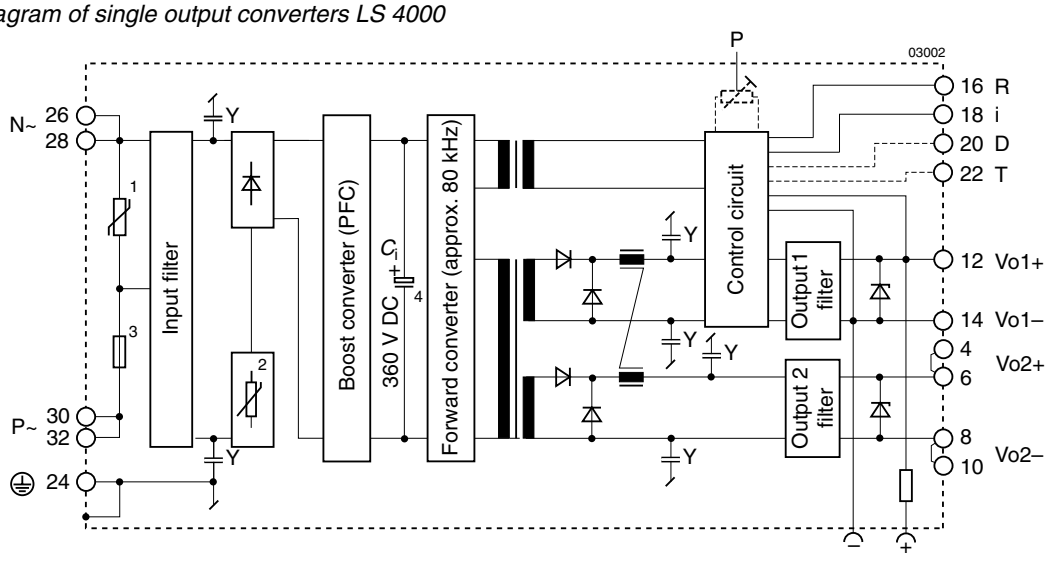


Fig. 2
Block diagram of symmetrical double output converters LS 5000

[1] Transient suppressor (VDR)
[2] Inrush current limiter (NTC or Opt. E), -9 versions exclude the NTC
[3] Input fuse
[4] Hold-up capacitor

Electrical Input Data

General Conditions
– T_A = 25°C, unless T_C is specified.
– Pin 18 connected to pin 14, U_o adjusted to $U_{o\ nom}$ (option P); R input not connected.
– Sense line pins S+ and S– connected to Vo+ and Vo– respectively.

Table 2: Input data

Input			LS			
Characteristics		Conditions	min	typ	max	Unit
U_i	Operating Input voltage	I_o = 0...$I_{o\ nom}$ $T_{C\ min}$...$T_{C\ max}$	85		255	V AC [3,4]
$U_{i\ nom}$	Nominal Input voltage			230		
I_i	Input current	$U_{i\ nom}$, $I_{o\ nom}$ [1]		0.55		A_{rms}
P_{i0}	No-load input power	$U_{i\ min}$...$U_{i\ max}$		9.0	10	W
$P_{i\ inh}$	Idle input power	unit inhibited		3.5	5	
R_i	Input resistance	T_C = 25°C	480			mΩ
R_{NTC}	NTC resistance [2]		3200	4000		
C_i	Input capacitance		80	100	120	µF
$U_{i\ RFI}$	Conducted input RFI	EN 55022 $U_{i\ nom}$, $I_{o\ nom}$		B		
	Radiated input RFI			B		
$U_{i\ abs}$	Input voltage limits without damage		–400		400	V DC
			–400		400	V_p

[1] With double output modules, both outputs loaded with $I_{o\ nom}$.
[2] Valid for -7 versions with NTC, (-9 versions exclude the NTC). Initial switch-on cycle. Subsequent switch-on/off cycles increase the inrush current peak value.
[3] AC frequency range 47...63 Hz.
[4] For DC-input please ask your local Power-One partner.

Input Fuse

A fuse mounted inside the converter protects the module against severe defects. (If operated from a DC-source this fuse may not fully protect the module when the input voltage exceeds 200 V DC! In applications where the converters operate at source voltages above 200 V DC an external fuse or a circuit breaker at system level should be installed!)

Table 3: Fuse Specification

Module	Fuse type	Fuse rating
LS [1]	slow-blow	SP T 4 A, 250 V

[1] Fuse size 5 × 20 mm

Input Under-/Overvoltage Lock-out

If the input voltage remains below approx. 65 V AC or exceeds approx. 280 V AC an internally generated inhibit signal disables the output(s). When checking this function the absolute maximum input voltage rating $U_{i\ abs}$ should be considered! Between $U_{i\ min}$ and the undervoltage lock-out level the output voltage may be below the value defined in table: *Output data* (see: *Technical Information: Measuring and Testing*).

Input Transient Protection

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

Reverse Polarity Protection

Should the input voltage to the unit be supplied from a DC source the built-in bridge rectifier provides reverse polarity protection. (For DC-input operation, please consult your local Power-One partner.)

Inrush Current Limitation

The modules of the versions -7, incorporate an NTC resistor in the input circuitry which – at initial turn on – reduces the peak inrush current value by a factor of 5...10 to protect connectors and switching devices from damage. Subsequent switch-on cycles within short periods will cause an increase of the peak inrush current value due to the warming-up of the NTC resistor. See also: *E option*.

Inrush Current Peak Value

The inrush current peak value (initial switch-on cycle) can be determined by following calculation:

$$I_{inr\ p} = \frac{U_{i\ rms} \bullet \sqrt{2}}{(R_{s\ ext} + R_i + R_{NTC})}$$

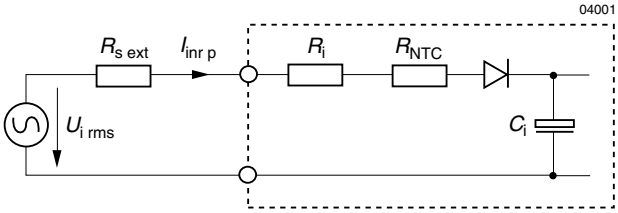


Fig. 3
Equivalent circuit diagram for input impedance.

Input Inrush Current Characteristic

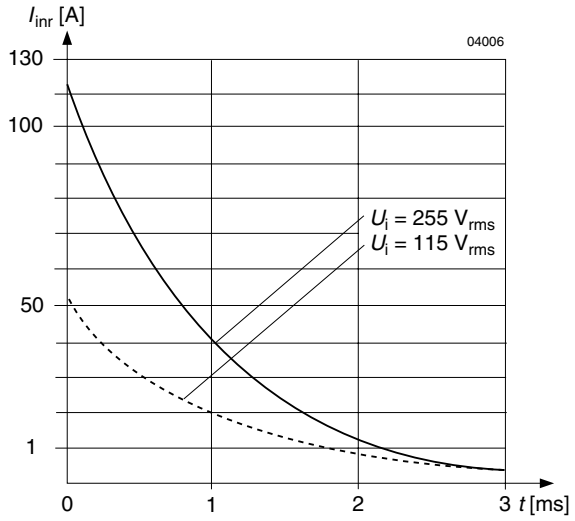


Fig. 4
Theoretical input inrush current versus time at U_i 255 V_{rms} and 115 V_{rms}, R_{ext} = 0.

Harmonic Currents

The harmonic distortion is well below the limits specified in IEC/EN 61000-3-2, class D.

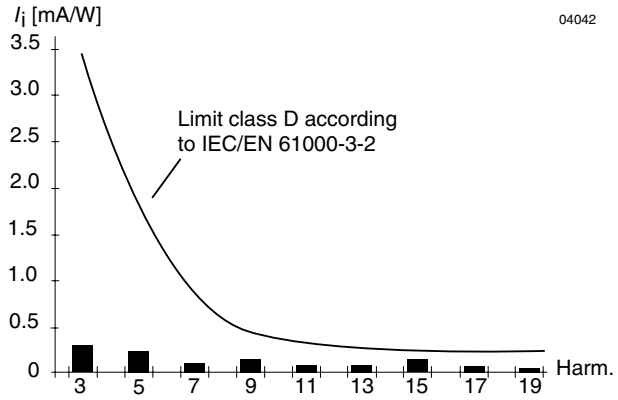


Fig. 5
Harmonic currents at the input, IEC/EN 61000-3-2, class D. $U_i = U_{i\,nom}$, $I_o = I_{o\,nom}$.

Static Input current Characteristic

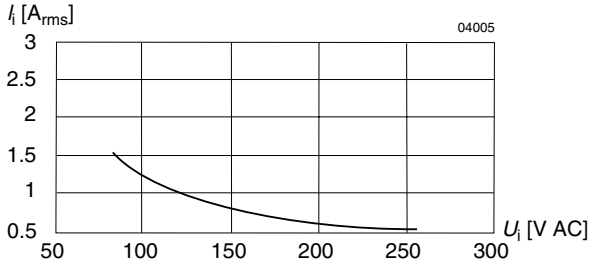


Fig. 6
Input current versus input voltage at $I_{o\,nom}$

Power Factor, Harmonics

Power factor correction is achieved by controlling the input current waveform synchronously with the input voltage waveform. The power factor control is active under all operating conditions.

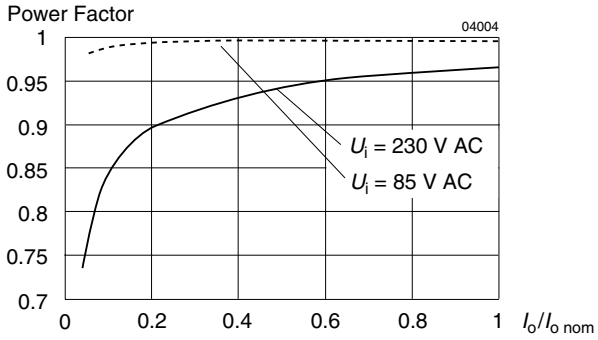


Fig. 7
Power factor versus output current at U_i 230 V AC and 85 V AC.

Electrical Output Data

General Conditions
– T_A = 25°C, unless T_C is specified.
– Pin 18 (i) connected to pin 14 (S–/Vo1–), U_o adjusted to $U_{o\,nom}$ (option P), R input not connected.
– Sense line pins 12 (S+) and 14 (S–) connected to pins 4 (Vo1+) and 8 (Vo1–) respectively.

Table 4a: Output data single output modules

Output				**LS 4001 5.1 V**			**LS 4301 12.0 V**			**LS 4501 15.0 V**			**LS 4601 24.0 V**			
Characteristics			Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	Unit
U_o	Output voltage		$U_{i\,nom}$, $I_{o\,nom}$	5.07		5.13	11.93		12.07	14.91		15.09	23.86		24.14	V
U_{op}	Overvoltage protection (supressor diode)				7.6			21			26.5			43.5		
$I_{o\,nom}$	Output current [1]		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$		16.0			8.0			6.5			4.2		A
I_{oL}	Output current limit [2]		$U_{i\,min}$...$U_{i\,max}$	16.2			8.2			6.7			4.4			
u_o [5]	Output voltage noise	Low frequency	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		2			2			2			2		mV_{pp}
		Switching freq.			15			5			5			5		
		Total			50			40			40			40		
$\Delta U_{o\,U}$	Static line regulation		$U_{i\,min}$...$U_{i\,nom}$, $U_{i\,nom}$...$U_{i\,max}$, $I_{o\,nom}$			±5			±12			±15			±24	mV
$\Delta U_{o\,I}$	Static load regulation		$U_{i\,nom}$, I_o = (0.1...1) $I_{o\,nom}$			20			24			30			48	
$u_{o\,d}$ [3]	Dynamic load regulat.	Voltage deviation	$U_{i\,nom}$, I_o = $I_{o\,nom} \leftrightarrow$ ½ $I_{o\,nom}$ IEC/EN 61204		±170			±150			±150			±100		
t_d [3]		Recovery time			0.3			0.4			0.4			0.3		ms
α_{Uo}	Temperature coefficient of output voltage [4]		$U_{i\,min}$...$U_{i\,max}$ 0...$I_{o\,nom}$		–0.5			-1.5			-1.5			1.5		mV/K

[1] If the output voltages are increased above $U_{o\,nom}$ through R-input control, option P setting, remote sensing or option T, the output currents should be reduced accordingly so that $P_{o\,nom}$ is not exceeded.
[2] See: *Output Voltage Regulation of Single or Double Output Modules with Outputs 1 and 2 Connected in Series.*
[3] See: *Typical dynamic load regulation of U_{o1} and U_{o2}.*
[4] Negative temperature coefficient (0...–3 mV/cell and K) available on request.
[5] Measured according to IEC/EN 61204 sub clause 3.10 with a probe acc. to annex A of the same standards. (See: *Technical Information: Measuring and Testing*)

Table 4b: Output data double output modules

Output (Outputs connected in Series)				**LS 5320 24 V (2 × 12 V)**			**LS 5540 30 V (2 × 15 V)**			**LS 5660 48 V (2 × 24 V)**			
Characteristics			Conditions	min	typ	max	min	typ	max	min	typ	max	Unit
U_o	Output voltage [2]		$U_{i\,nom}$, $I_{o\,nom}$		24.0			30.0			48.0		V
U_{op}	Overvoltage protection (supressor diode)				38			48			74		
$I_{o\,nom}$	Output current [1]		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$		4.0			3.2			2.0		A
I_{oL}	Output current limit [4]		$U_{i\,min}$...$U_{i\,max}$	4.2			3.4			2.1			
u_o [7]	Output voltage noise [3]	Low frequency	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		3			3			5		mV_{pp}
		Switching freq.			15			15			20		
		Total			100			100			150		
$\Delta U_{o\,U}$	Static line regulation		$U_{i\,min}$...$U_{i\,max}$ $I_{o\,nom}$			±12			±15			±24	mV
$\Delta U_{o\,I}$	Static load regulation		$U_{i\,nom}$, I_o = (0.1...1) $I_{o\,nom}$			40			60			96	
$u_{o\,d}$ [5]	Dynamic load regulat.	Voltage deviation	$U_{i\,nom}$, I_o = $I_{o\,nom} \leftrightarrow {}^1/_2\, I_{o\,nom}$ IEC/EN 61204		±250			±200			±150		
t_d [5]		Recovery time			0.3			0.3			0.3		ms
α_{Uo}	Temperature coefficient of output voltage [6]		$U_{i\,min}$...$U_{i\,max}$ 0...$I_{o\,nom}$		–2.2			–2.2			–2.6		mV/K

[1] If the output voltages are increased above $U_{o\,nom}$ through R-input control, option P setting, remote sensing or option T, the output currents should be reduced accordingly so that $P_{o\,nom}$ is not exceeded.
[2] Series connection for $U_{o\,nom}$ = 24 V, 30 V or 48 V, see: *R-Function for different output configurations.*
[3] Shortest possible wiring for series connection at the connector.
[4] See: *Output Voltage Regulation of Single or Double Output Modules with Outputs 1 and 2 Connected in Series.*
[5] See: *Typical dynamic load regulation of U_{o1} and U_{o2}.*
[6] Negative temperature coefficient (0...-3 mV/cell and K) available on request.
[7] Measured according to IEC/EN 61204 sub clause 3.10 with a probe acc. to annex A of the same standards. (See: *Technical Information: Measuring and Testing*)

Table 4c: Output data double output modules

Output (Outputs independently loaded) [1]				**LS 5320 12 V/12 V**						**LS 5540 15 V/15 V**						
Characteristics			Conditions	Output 1			Output 2			Output 1			Output 2			
				min	typ	max	min	typ	max	min	typ	max	min	typ	max	Unit
U_o	Output voltage		$U_{i\,nom}$, $I_{o\,nom}$ [2]	11.93		12.07	11.82		12.18	14.91		15.09	14.78		15.23	V
U_{op}	Overvoltage protection (supressor diode)				19			19			24			24		
$I_{o\,nom}$	Output current [3]		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$		4.0			4.0			3.2			3.2		A
I_{oL}	Output current limit [4]		$U_{i\,min}$...$U_{i\,max}$	4.2			4.2			3.4			3.4			
u_o [8]	Output voltage noise	Low frequency	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		3			3			3			3		mV_{pp}
		Switching freq.			12			12			10			10		
		Total			80			40			100			40		
$\Delta U_{o\,U}$	Static line regulation		$U_{i\,min}$...$U_{i\,nom}$ $U_{i\,nom}$...$U_{i\,max}$ $I_{o\,nom}$			±12			±12			±15			±15	mV
$\Delta U_{o\,I}$	Static load regulation		$U_{i\,nom}$, I_o = (0.1...1) $I_{o\,nom}$ [5]			48		[5]				60		[5]		
$u_{o\,d}$ [6]	Dynamic load regulat.	Voltage deviation	$U_{i\,nom}$, I_o = $I_{o\,nom} \leftrightarrow {}^1/_2\, I_{o\,nom}$ IEC/EN 61204		±100						±100					
t_d [6]		Recovery time			0.3						0.3					ms
α_{Uo}	Temperature coefficient of output voltage [7]		$U_{i\,min}$...$U_{i\,max}$ 0...$I_{o\,nom}$		–1.5						–1.5					mV/K

Table 4d: Output data double output modules

Output (Outputs independently loaded) [1]				**LS 5660 24 V/24 V**						
Characteristics			Conditions	Output 1			Output 2			
				min	typ	max	min	typ	max	Unit
U_o	Output voltage		$U_{i\,nom}$, $I_{o\,nom}$ [2]	23.86		24.14	23.64		24.36	V
U_{op}	Overvoltage protection (supressor diode)				37			37		
$I_{o\,nom}$	Output current [3]		$U_{i\,min}$...$U_{i\,max}$ $T_{C\,min}$...$T_{C\,max}$		2.0			2.0		A
I_{oL}	Output current limit [4]		$U_{i\,min}$...$U_{i\,max}$	2.1			2.1			
u_o [8]	Output voltage noise	Low frequency	$U_{i\,nom}$, $I_{o\,nom}$ IEC/EN 61204 BW = 20 MHz		3			3		mV_{pp}
		Switching freq.			10			10		
		Total			100			40		
$\Delta U_{o\,U}$	Static line regulation		$U_{i\,min}$...$U_{i\,nom}$, $U_{i\,nom}$...$U_{i\,max}$, $I_{o\,nom}$			±24			±24	mV
$\Delta U_{o\,I}$	Static load regulation		$U_{i\,nom}$, I_o = (0.1...1) $I_{o\,nom}$ [5]			96		[5]		
$u_{o\,d}$ [6]	Dynamic load regulat.	Voltage deviation	$U_{i\,nom}$, I_o = $I_{o\,nom} \leftrightarrow {}^1/_2\, I_{o\,nom}$ IEC/EN 61204		±80					
t_d [6]		Recovery time			0.3					ms
α_{Uo}	Temperature coefficient of output voltage [7]		$U_{i\,min}$...$U_{i\,max}$ 0...$I_{o\,nom}$		–0.5					mV/K

[1] Depending upon the desired output configuration the wiring should be made as shown in: *R-Function for different output configurations.*

[2] Same conditions for both outputs.

[3] If the control voltages are increased above $U_{o\,nom}$ via R-input control, option Psetting, remote sensing or option T, the output currentsshould be reduced accordingly so that $P_{o\,nom}$ is not exceeded.

[4] See: *Output Voltage Regulation of Single or Double Output Modules with Outputs 1 and 2 Connected in Series.*

[5] Condition for specified output. Other output loaded with constant current I_o = $I_{o\,nom}$. See: *Output voltage regulation of double output units.*

[6] See: *Typical dynamic load regulation of U_{o1} and U_{o2}.*

[7] Negative temperature coefficient (0....–3 mV/cell and K) available on request.

[8] Measured according to IEC/EN 61204 sub clause 3.10 with a probe acc. to annex A of the same standards.

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 at its nominal input voltage and output power, 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 on 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 an additional heat sink allows T_A to be higher than 71 °C (e.g. 85 °C) if $T_{C\,max}$ is not exceeded.

For -7 or -9 units at an ambient temperature T_A of 85 °C with only convection cooling, the maximum permissible current for each output is approx. 40% of its nominal value as per figure.

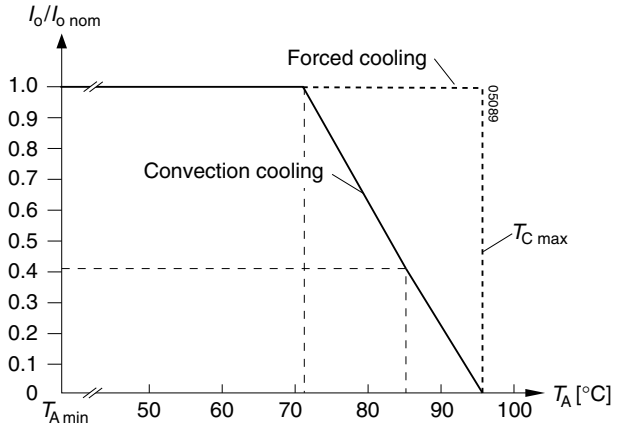


Fig. 8
Output current derating versus temperature for -7 and -9 units.

Thermal Protection

A temperature sensor generates an internal inhibit signal which disables the outputs if the case temperature exceeds $T_{C\,max}$. The outputs are automatically re-enabled if the temperature drops below this limit.

It is recommended that continuous operation under simultaneous extreme worst case conditions of the following three parameters be avoided: Minimum input voltage, maximum output power and maximum temperature.

Output Protection

Each output is protected against overvoltage which could occur due to a failure of the control circuit by means of a voltage suppressor diode which, under worst case conditions, may become a short circuit. The suppressor diodes are not designed to withstand externally applied overvoltages. Overload at any of the two outputs will cause a shut-down of both outputs. A red LED indicates the overload condition.

Parallel or Series Connection of Units

Single or double output units with equal nominal output voltage can be connected in parallel without any precautions using option T.

With option T (current sharing), all units share the current approximately equally.

Single output units and/or main and second outputs of double output units can be connected in series with any other (similar) output.

Note:
- Parallel connection of double output units should always include both, main and second output to maintain good regulation of both outputs.
- Not more than 5 units should be connected in parallel.
- Series connection of second outputs without involving their main outputs should be avoided as regulation may be poor.
- The maximum output current is limited by the output with the lowest current limitation if several outputs are connected in series.

Output Voltage Regulation of Single or Double Output Modules with Outputs 1 and 2 Connected in Series

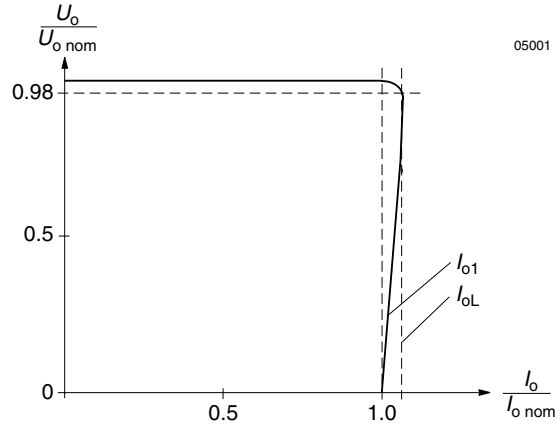


Fig. 9
U_{o1} vs. I_{o1} (typ.) of single output units

Output Voltage Regulation of Double Output Modules

Output 1 is under normal conditions regulated to $U_{o1\,nom}$, independent of the output currents.

U_{o2} is dependent upon the load distribution. If both outputs are loaded with more than 10% of $I_{o\,nom}$, the deviation of U_{o2} remains within ±5% of the value of U_{o1}. The following 3 figures show the regulation with varying load distribution. If $I_{o1} = I_{o2}$ or the two outputs are connected in series, the deviation of U_{o2} remains within ±1% of the value of U_{o1} provided that a total load of more than 10% of $I_{o\,nom}$ is applied.

Two outputs of a single S 5000 module connected in parallel will behave like the output of a S 4000 module; the paralleled output is fully regulated. No precautions are necessary in using the R-input and the test sockets.

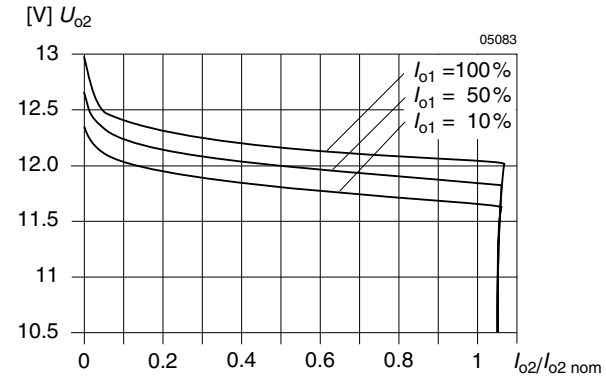


Fig. 10
LS 5320: ΔU_{o2} (typ.) vs. I_{o2} with different I_{o1}.

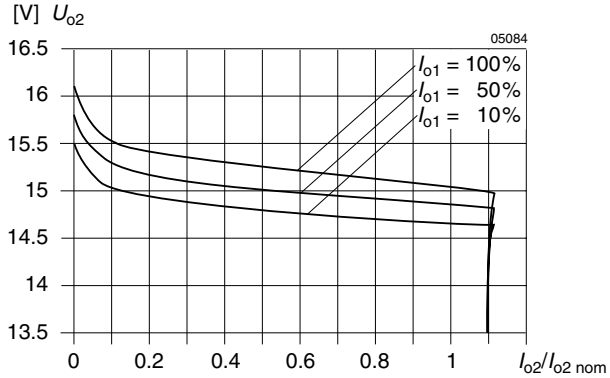


Fig. 11
LS 5540: ΔU_{o2} (typ.) vs. I_{o2} with different I_{o1}.

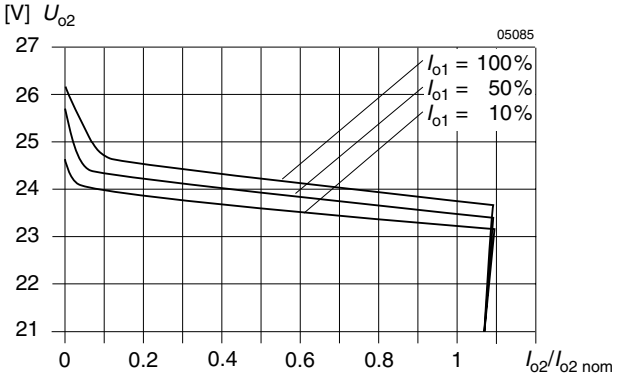


Fig. 12
LS 5660: ΔU_{o2} (typ.) vs. I_{o2} with different I_{o1}.

Switching Frequency versus Load

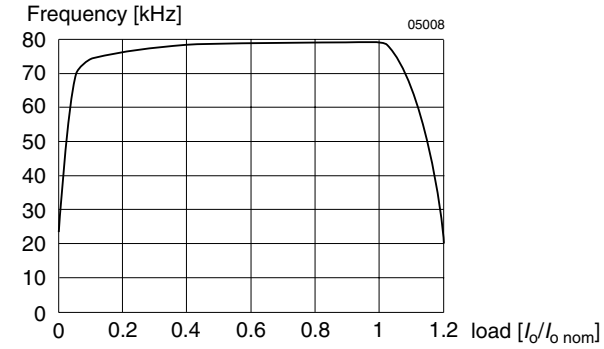


Fig. 13
Switching frequency versus load. (The boost converter at the input stage has a fixed frequency of 100 kHz)

Dynamic Load Regulation

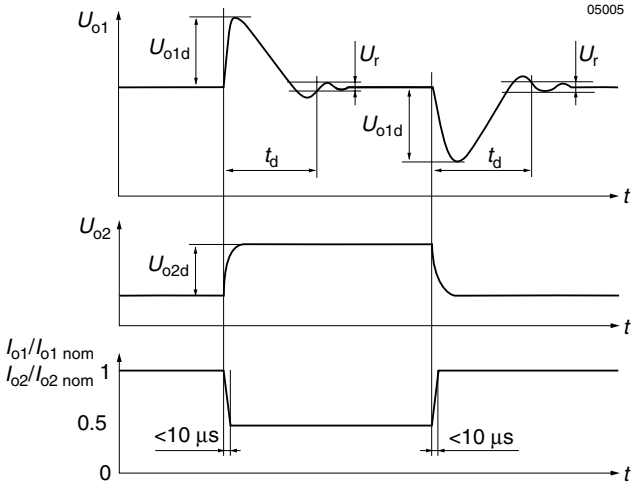


Fig. 14
Typical dynamic load regulation of U_{o1} and U_{o2}.

Hold-up Time versus Output Power

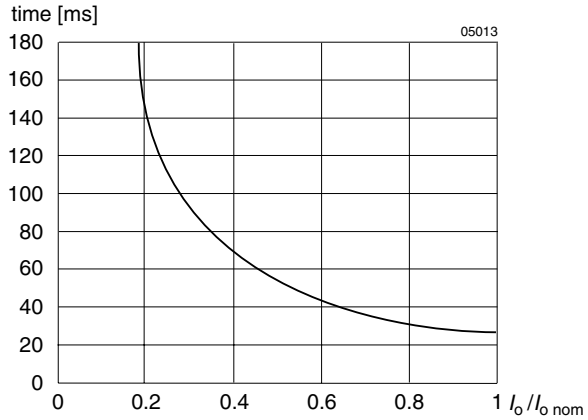


Fig. 15
Hold-up time t_h versus output power.

Efficiency versus Load

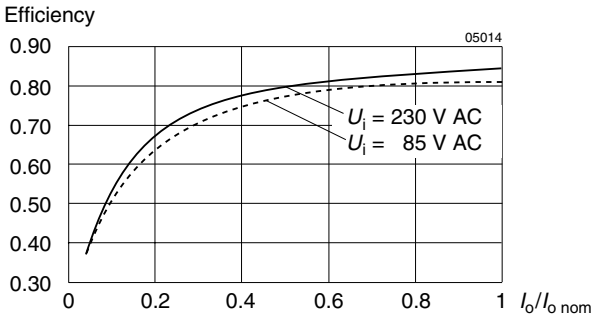


Fig. 16
Efficiency versus load at U_i; 230 V AC and 85 V AC

Auxiliary Functions

i Inhibit for Remote On and Off

Note: With open i input: Output is disabled (U_o = off).

The outputs of the module may be enabled or disabled by means of a logic signal (TTL, CMOS, etc.) applied between the inhibit input i and the negative pin of output 1 (Vo1–). In systems with several units, this feature can be used, for example, to control the activation sequence of the converters. If the inhibit function is not required, connect the inhibit pin 18 to pin 14 to enable the outputs (active low logic, fail safe). For output response refer to: *Hold-up Time and Output Response*.

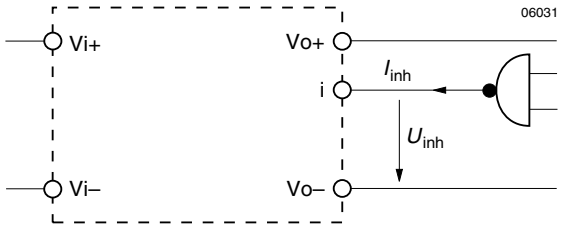


Fig. 17
Definition of U_{inh} and I_{inh}.

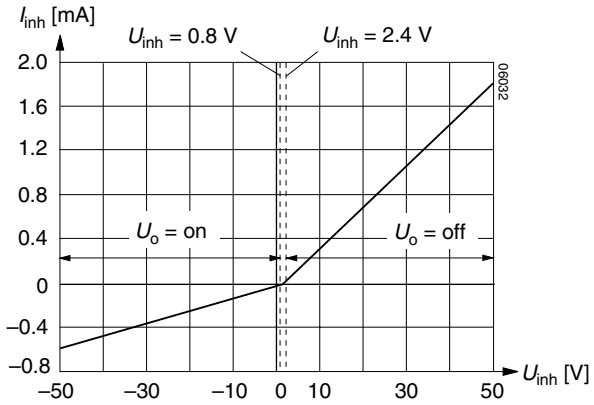


Fig. 18
Typical inhibit current I_{inh} versus inhibit voltage U_{inh}

Table 5: Inhibit characteristics

Characteristic			Conditions	min	typ	max	Unit
U_{inh}	Inhibit voltage	U_o = on	$U_{i\,min}$…$U_{i\,max}$	–50		0.8	V
		U_o = off		2.4		50	
I_{inh}	Inhibit current		U_{inh} = 0			–400	µA
t_r	Rise time				30		ms
t_f	Fall time		depending on I_o				

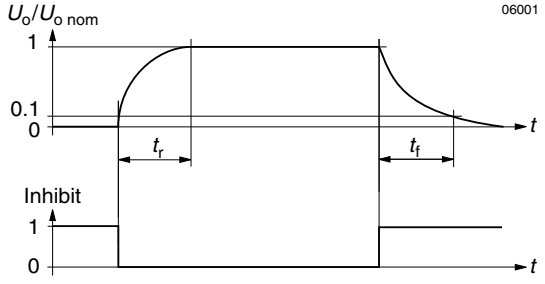


Fig. 19
Output response as a function of inhibit control

Sense Lines

(Only for single output units 5.1 V, 12 V, 15 V, 24 V)

This feature enables for compensation of voltage drops across the connector contacts and if necessary, across the load lines. If the sense lines are connected at the load rather than directly at the connector, the user should ensure that $U_{o\,max}$ (between Vo1+ and Vo1–) is not exceeded. We recommend connecting the sense lines directly at the female connector.

For further information, please refer to: *Application Notes* .

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

Table 6: Maximum Voltage compensation allowed using sense lines

Output voltage	Total voltage difference between sense lines and their respective outputs	Voltage difference between Vo– and S–
5.1 V	<0.5 V	<0.25 V
12 V, 15 V	<1.0 V	<0.25 V

If the output voltages are increased above $U_{o\,nom}$ via R-input control, option P setting, remote sensing or option T, the output currents must be reduced accordingly so that $P_{o\,nom}$ is not exceeded.

Important: The output terminals Vo1+ and Vo1– must always be connected to the load before connecting the sense lines S+ and S–, otherwise the unit will be damaged.

Programmable Output Voltage (R-Function)

As a standard feature, the modules offer an adjustable output voltage, identified by letter R in the type designation. The control input R (pin 16) accepts either a control voltage U_{ext} or a resistor R_{ext} to adjust the desired output voltage. When not connected, the control input automatically sets the output voltage to $U_{o\,nom}$.

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

The control voltage range is 0...2.75 V DC and allows an output voltage adjustment in the range of approximately 0...110% $U_{o\,nom}$.

$$U_{ext} = \frac{U_o}{U_{o\,nom}} \bullet 2.5\ V \text{ (approximate formula)}$$

b) Adjustment by means of an external resistor:

Depending upon the value of the required output voltage the resistor shall be connected

either: Between pin 16 and pin 14 ($U_o < U_{o\,nom}$) to achieve an output voltage adjustment range of approximately 0...100% $U_{o\,nom}$

or: Between pin 16 and pin 12 ($U_o > U_{o\,nom}$) to achieve an output voltage adjustment range of approximately 100...110% $U_{o\,nom}$.

Warning:

- U_{ext} shall never exceed 2.75 V DC.
- The value of R'_{ext} shall never be less than the lowest value as indicated in table R'_{ext} (for $U_0 > U_{0\,nom}$) to avoid damage to the unit!

Remarks:

- The R-Function excludes option P (output voltage adjustment by potentiometer).
- If the output voltages are increased above $U_{o\,nom}$ via R-input control, option P setting, remote sensing or option T, the output current(s) should be reduced accordingly so that $P_{o\,nom}$ is not exceeded.
- The R-input (as well as option P) is related to the main output.
- With double output units the second output follows the value of the controlled main output. Resistor values as indicated for the single output units should be used.
- For correct output voltage adjustment of double output units the external wiring of the outputs should be according to fig.: *R-Function for different output configuration* depending upon the desired output configuration.
- In case of parallel connection the output voltages should be individually set within a tolerance of 1...2%.

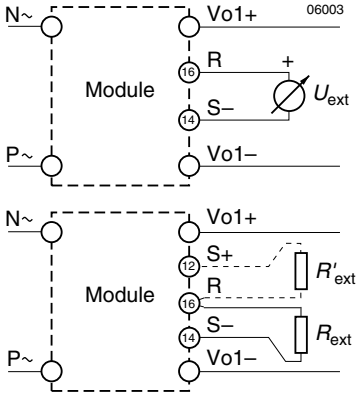


Fig. 20
Output voltage control for single output units LS 4000 by means of the R input

Table 7a: R_{ext} for $U_o < U_{o\,nom}$; approximative values ($U_{i\,nom}$, $I_{o\,nom}$, series E 96 resistors); $R'_{ext} = \infty$

$U_{o\,nom}$ = 5.1 V		$U_{o\,nom}$ = 12 V			$U_{o\,nom}$ = 15 V			$U_{o\,nom}$ = 24 V		
U_o (V)	R_{ext} [kΩ]	U_o [V] [1]		R_{ext} [kΩ]	U_o [V] [1]		R_{ext} [kΩ]	U_o [V] [1]		R_{ext} [kΩ]
0.5	0.432	2	4	0.806	2	4	0.619	4	8	0.806
1.0	0.976	3	6	1.33	4	8	1.47	6	12	1.33
1.5	1.65	4	8	2	6	12	2.67	8	16	2
2.0	2.61	5	10	2.87	8	16	4.53	10	20	2.87
2.5	3.83	6	12	4.02	9	18	6.04	12	24	4.02
3.0	5.76	7	14	5.62	10	20	8.06	14	28	5.62
3.5	8.66	8	16	8.06	11	22	11	16	32	8.06
4.0	14.7	9	18	12.1	12	24	16.2	18	36	12.1
4.5	30.1	10	20	20	13	26	26.1	20	40	20
5.0	200	11	22	42.2	14	28	56.2	22	44	44.2

Table 7b: R'_{ext} for $U_o > U_{o\,nom}$; approximative values ($U_{i\,nom}$, $I_{o\,nom}$, series E 96 resistors); $R_{ext} = \infty$

$U_{o\,nom}$ = 5.1 V		$U_{o\,nom}$ = 12 V			$U_{o\,nom}$ = 15 V			$U_{o\,nom}$ = 24 V		
U_o [V]	R'_{ext} [kΩ]	U_o [V] [1]		R'_{ext} [kΩ]	U_o [V] [1]		R'_{ext} [kΩ]	U_o [V] [1]		R'_{ext} [kΩ]
5.15	432	12.1	24.2	1820	15.2	30.4	1500	24.25	48.5	3320
5.2	215	12.2	24.4	931	15.4	30.8	768	24.5	49.0	1690
5.25	147	12.3	24.6	619	15.6	31.2	523	24.75	49.5	1130
5.3	110	12.4	24.8	475	15.8	31.6	392	25.0	50.0	845
5.35	88.7	12.5	25.0	383	16.0	32.0	316	25.25	50.5	698
5.4	75	12.6	25.2	316	16.2	32.4	267	25.5	51.0	590
5.45	64.9	12.7	25.4	274	16.4	32.8	232	25.75	51.5	511
5.5	57.6	12.8	25.6	243	16.5	33.0	221	26.0	52.0	442
		13.0	26.0	196				26.25	52.5	402
		13.2	26.4	169				26.4	52.8	383

[1] First column: single output units or double output units with separated outputs, second column: outputs in series connection

R-Function for different output configurations

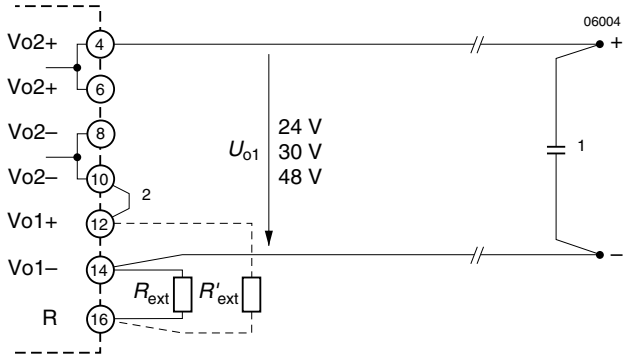


Fig. 21a
LS 5000 with H15 connector. R-input for output voltage control. Wiring for output voltage 24 V or 30 V or 48 V with main and second output connected in series.

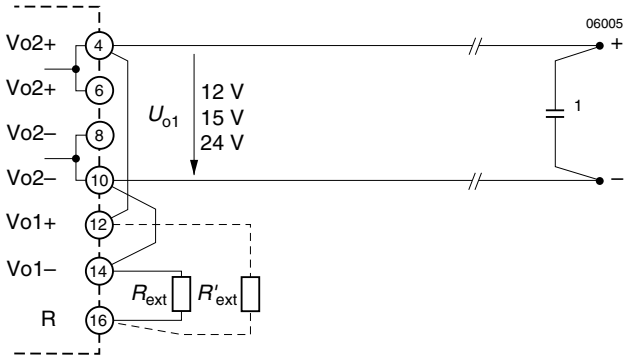


Fig. 21b
LS 5000 with H15 connector. R-input for output voltage control. Wiring for output voltage 12 V or 15 V or 24 V with main and second output connected in parallel.

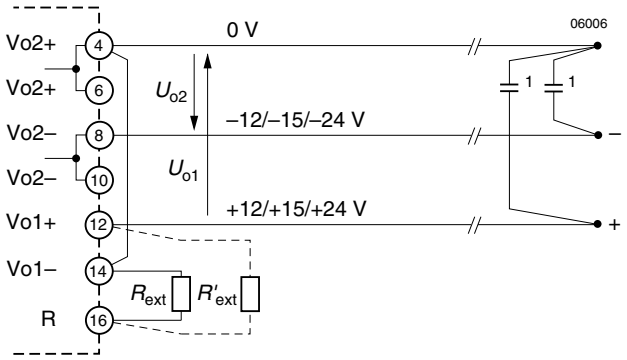


Fig. 21c
LS 5000 with H15 connector. R-input for output voltage control. Wiring of main and second output for two symmetrical output voltages U_{o1} and U_{o2}: ±12 V or ±15 V or ±24 V.

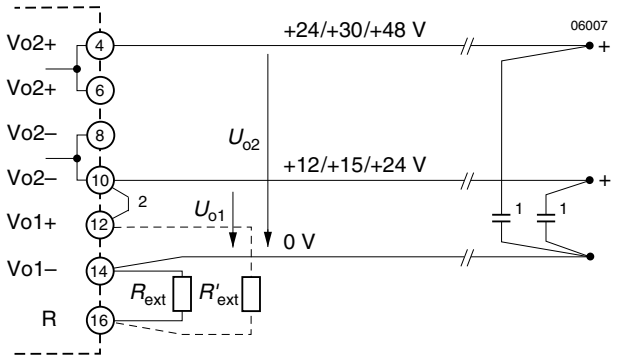


Fig. 21d
LS 5000 with H15 connector. R-input for output voltage control. Wiring of main and second output for two output voltages U_{o1} and U_{o2}: +12 V and +24 V or +15 V and +30 V or +24 V and +48 V.

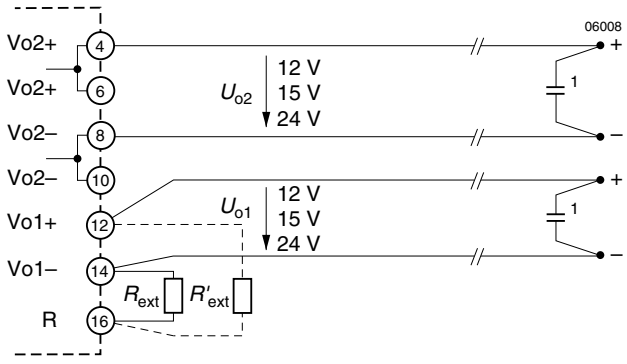


Fig. 21e
LS 5000 with H15 connector. R-input for output voltage control. Wiring of main and second output for two output voltages U_{o1} and U_{o2}: 12 V/12 V or 15 V/15 V or 24 V/24 V, the outputs are galvanically isolated.

[1] A ceramic multilayer capacitor connected across the load reduces ripple and spikes.
[2] Shortest possible wiring for series connection at the female connector

Remarks:

Double output units fitted with H15 connectors have the output pins of the second output, pins 4/6 and 8/10, internally paralleled.

It is recommended that pins 4/6 and 8/10 be directly paralleled at the female connector as well to reduce the voltage drop across the connector.

Please note: U_{o2} varies depending upon its own load and the load on output 1.

Display Status of LEDs

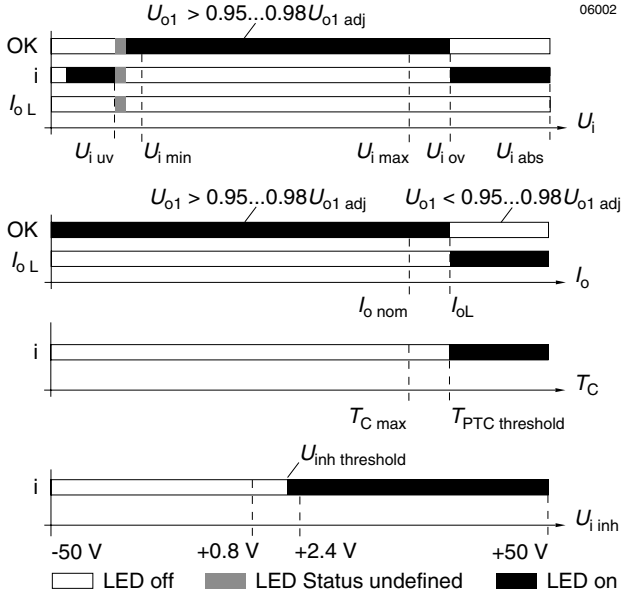


Fig. 22
LEDs "OK", "i" and "$I_{o\ L}$" status versus input voltage
Conditions: $I_o \leq I_{o\ nom}$, $T_C \leq T_{C\ max}$, $U_{inh} \leq 0.8$ V
$U_{i\ uv}$ = undervoltage lock-out, $U_{i\ ov}$ = overvoltage lock-out

LEDs "OK" and "$I_{o\ L}$" status versus output current
Conditions: $U_{i\ min}$...$U_{i\ max}$, $T_C \leq T_{C\ max}$, $U_{inh} \leq 0.8$ V

LED "i" versus case temperature
Conditions: $U_{i\ min}$...$U_{i\ max}$, $I_o \leq I_{o\ nom}$, $U_{inh} \leq 0.8$ V

LED "i" versus U_{inh}
Conditions: $U_{i\ min}$...$U_{i\ max}$, $I_o \leq I_{o\ nom}$, $T_C \leq T_{C\ max}$

Battery Charging/Temperature Sensor

The LS are intended for lead acid battery charger applications. For an optimum battery charging and life expectancy of the battery an external temperature sensor may be connected to the R-input. The sensor is mounted as close as possible to the battery pole and adjusts the output voltage of the LS unit according to the temperature of the battery (which is related to the load of the battery and the ambient temperature).

Depending on the cell voltage and the temperature coefficient of the battery, different sensor types are available.

For more information please ask Power-One.

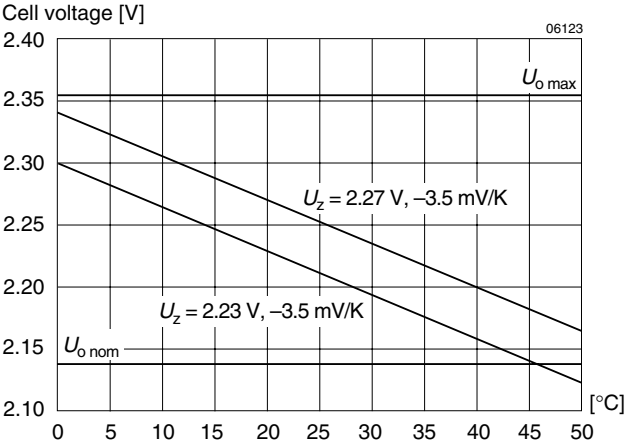


Fig. 17
Dependance of output voltage vs. temperature for defined temperature coefficient.

Test Sockets (Main output only)

Test sockets for measuring the output voltage U_{o1} are located at the front of the module. The positive test socket is protected by a series resistor (see: *Functional Description, block diagrams*). The voltage measured at the test sockets is approximately 30 mV lower than the value measured at the output terminals.

In case of double output units externally connected in series for U_o = 24 V, 30 V or 48 V the monitored output voltage is 12 V, 15 V or 24 V respectively.

Electromagnetic Compatibility (EMC)

A metal oxide VDR together with an input fuse and an input filter form an effective protection against high input transient voltages which typically occur in most installations. The S series has been successfully tested to the following specifications:

Electromagnetic Immunity

Table 8: Immunity type tests

Phenomenon	Standard [1]	Level	Coupling mode [2]	Value applied	Waveform	Source imped.	Test procedure	In oper.	Perform. [3]
Voltage surge	IEC 60571-1		i/c, +i/–i	800 V_p	100 µs	100 Ω	1 pos. and 1 neg. voltage surge per coupling mode	yes	[4]
				1500 V_p	50 µs				
				3000 V_p	5 µs				
				4000 V_p	1 µs				
				7000 V_p	100 ns				
Supply related surge	RIA 12	B	+i/–i	1.5 • U_{batt}	1 s	0.2 Ω	1 positive surge	yes	[4]
Direct transient		C	+i/c, –i/c	960 V_p	10/100 µs	5 Ω	5 pos. and 5 neg. impulses	yes	[4]
		D		1800 V_p	5/50 µs				
		E		3600 V_p	0.5/5 µs	100 Ω			
		F		4800 V_p	0.1/1 µs				
		G		8400 V_p	0.05/0.1 µs				
Indirect coupled transient		H	–o/c, +o/c	1800 V_p	5/50 µs				
		J		3600 V_p	0.5/5 µs				
		K		4800 V_p	0.1/1 µs				
		L		8400 V_p	0.05/0.1 µs				
Electrostatic discharge (to case)	IEC/EN 61000-4-2	4	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	3	antenna	10 V/m	AM 80% 1 kHz	n.a.	80…1000 MHz	yes	A
Electromagnetic field, pulse modulated	ENV 50204				50% duty cycle, 200 Hz repetition frequency		900 ±5 MHz	yes	A
Electrical fast transient/burst	IEC/EN 61000-4-4	4	capacitive, o/c	2000 V_p	bursts of 5/50 ns 2.5/5 kHz over 15 ms; burst period: 300 ms	50 Ω	1 min positive 1 min negative transients per coupling mode	yes	A
			i/c, +i/–i direct	4000 V_p					A
Surge	IEC/EN 61000-4-5	3	i/c	2000 V_p	1.2/50 µs	12 Ω	5 pos. and 5 neg. surges per	yes	A
		4	+i/–i			2 Ω			
			i/c, +i/–i	2500 V_p	10/700 µs	40 Ω			
Conducted disturbances	IEC/EN 61000-4-6	3	i, o, signal wires	10 V_{rms} (140 dBµV)	AM 80% 1 kHz	150 Ω	0.15...80 MHz	yes	A

[1] Related and previous standards are referenced in: *Technical Information: Standards*.
[2] i = input, o = output, c = case.
[3] A = Normal operation, no deviation from specifications, B = Normal operation, temporary deviation from specs possible.
[4] Test in progress, please consult factory.

Note: Previous standards are referenced in: *Technical Information: Standards*

Electromagnetic Emission

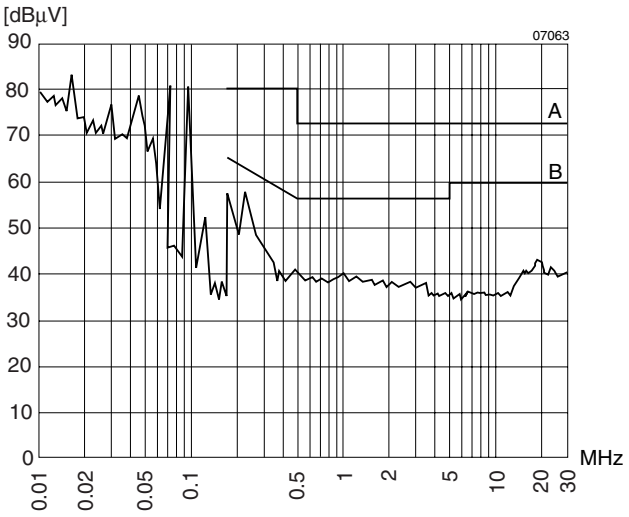


Fig. 23
Typical disturbance voltage (quasi-peak) at the input according to CISPR 11/22 and EN 55011/22, measured at $U_{i\ nom}$ and $I_{o\ nom}$.

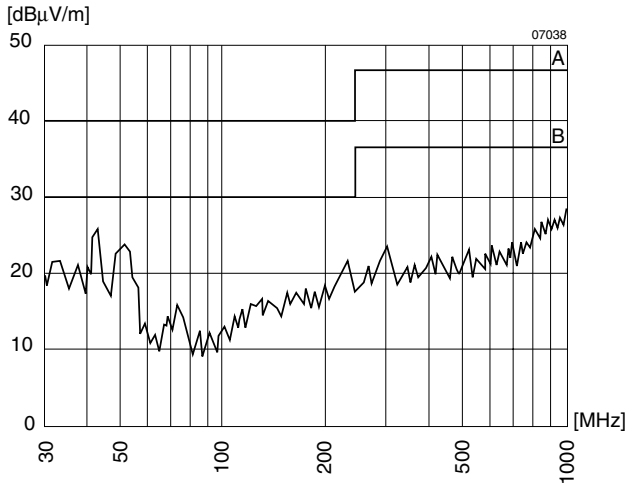


Fig. 24
Typical radiated electromagnetic field strength (quasi-peak) according to CISPR 11/22 and EN 55011/22, normalized to a distance of 10 m, measured at $U_{i\ nom}$ and $I_{o\ nom}$.

Immunity to Environmental Conditions

Table 9: Environment specifications

Test method		Standard	Test conditions		Status
Ca	Damp heat steady state	IEC/DIN IEC 60068-2-3 MIL-STD-810D section 507.2	Temperature: Relative humidity: Duration:	40 $^{\pm 2}$ °C 93 $^{+2/-3}$ % 56 days	Unit not operating
Ea	Shock (half-sinusoidal)	IEC/EN/DIN EN 60068-2-27 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	100 g_n = 981 m/s^2 6 ms 18 (3 each direction)	Unit operating
Eb	Bump (half-sinusoidal)	IEC/EN/DIN EN 60068-2-29 MIL-STD-810D section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	40 g_n = 392 m/s^2 6 ms 6000 (1000 each direction)	Unit operating
Fc	Vibration (sinusoidal)	IEC/EN/DIN EN 60068-2-6	Acceleration amplitude: Frequency (1 Oct/min): Test duration:	0.35 mm (10...60 Hz) 5 g_n = 49 m/s^2 (60...2000 Hz) 10...2000 Hz 7.5 h (2.5 h each axis)	Unit operating
Fn	Vibration broad band random (digital dontrol)	IEC 60068-2-64 DIN 40046 part 23 MIL-STD-810D section 514.3	Acceleration spectral density: Frequency band: Acceleration magnitude: Test duration:	0.05 g_n^2/Hz 5...500 Hz 4.97 $g_{n\ rms}$ 3 h (1 h each axis)	Unit operating
Kb	Salt mist, cyclic (sodium chloride NaCl solution)	IEC/EN/DIN IEC 60068-2-52	Concentration: Duration: Storage: Storage duration: Number of cycles:	5% (30°C) 2 h per cycle 40°C, 93% rel. humidity 22 h per cycle 3	Unit not operating

Table 10: Temperature specifications, values given are for an air pressure of 800...1200 hPa (800...1200 mbar)

Temperature			Standard -7		Option -9		
Characteristics		Conditions	min	max	min	max	Unit
T_A	Ambient temperature	$U_{i\ min}$...$U_{i\ max}$ I_o = 0...$I_{o\ nom}$	–25	71	–40	71	°C
T_C	Case temperature		–25	95	–40	95	
T_S	Storage temperature	Not operational	–40	100	–55	100	

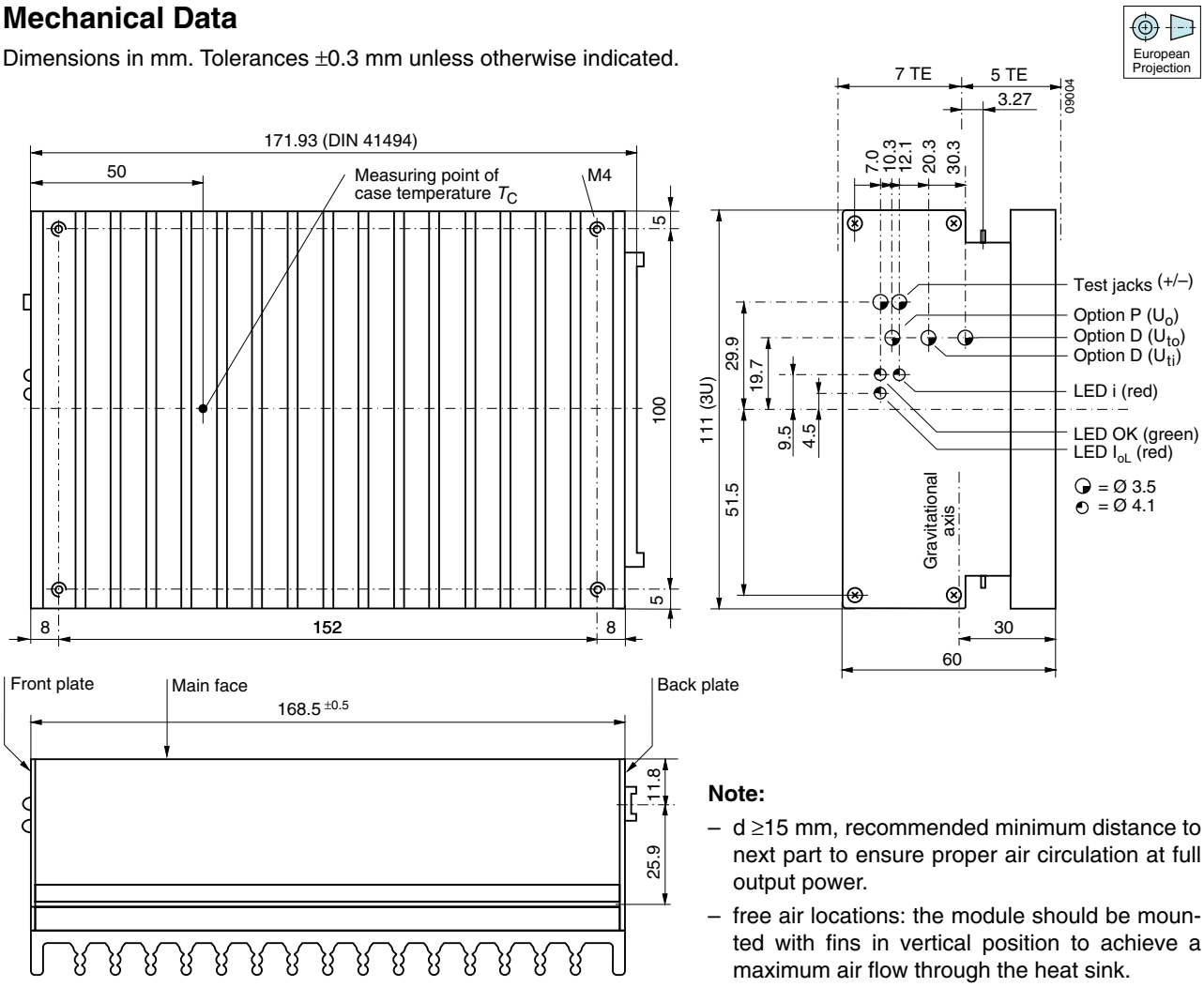
Table 11: MTBF

Values at Specified Case Temperature	Type	Ground Benign 40°C	Ground Fixed 40°C	Ground Fixed 70°C	Ground Mobile 50°C	Unit
MTBF [1]	LS 4000/5000	514'000	88'000	38'000	35'000	h

[1] Calcualted in accordance with MIL-HDBK217F.

Mechanical Data

Dimensions in mm. Tolerances ±0.3 mm unless otherwise indicated.

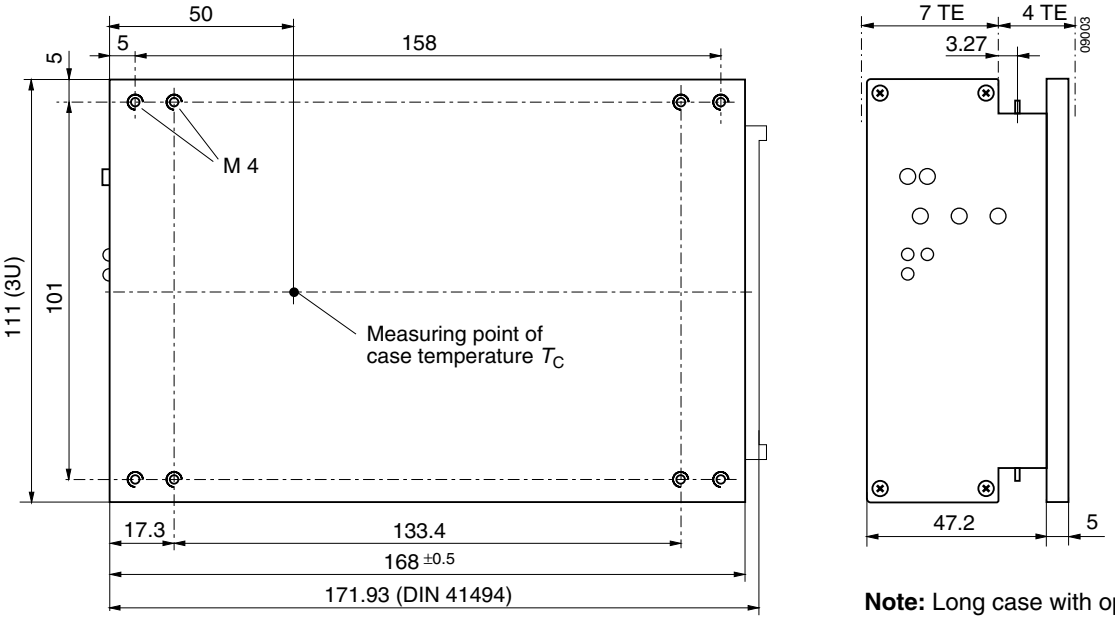


Note:

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

– free air locations: the module should be mounted with fins in vertical position to achieve a maximum air flow through the heat sink.

Fig. 25
Aluminium case S02 with heatsink, black finish and self cooling, weight: Approx. 1.25 kg



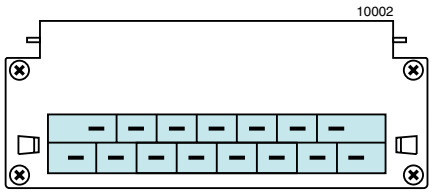
Note: Long case with option B2, elongated by 60 mm for 220 mm rack depth, is available on request. (No LEDs, no test jacks.)

Fig. 26
Aluminium case S02 with option B1 (cooling plate), black finish and self cooling. Total weight: Approx. 1.15 kg

Safety and Installation Instructions

Connector Pin Allocation

The connector pin allocation table defines the electrical potentials and the physical pin positions on the H15 connector. Pin no. 24, the protective earth pin present on all LS AC-DC converters is leading, ensuring that it makes contact with the female connector first.



Type H15

Fig. 27
View of module's male H15 connector

Table 12: H15 Connector pin allocation

Pin	Connector type H 15			
No.	LS 4000		LS 5000	
4	Vo1+	Output 1	Vo2+	Output 2
6	Vo1+		Vo2+	
8	Vo1–	Output 1	Vo2–	Output 2
10	Vo1–		Vo2–	
12	S+	Sense	Vo1+	Output 1
14	S–	Sense	Vo1–	Output 1
16	R [1]	Control of U_{o1}	R [1]	Control of U_{o1}
18	i	Inhibit	i	Inhibit
20	D	Save data	D	Save data
	V [3]	ACFAIL		
22	T	Current sharing	T	Current sharing
24 [2]	⏚	Protective earth	⏚	Protective earth
26	N~	Neutral	N~	Neutral
28	N~		N~	
30	P~	Phase	P~	Phase
32	P~		P~	

[1] Feature R excludes option P and vice versa
[2] Leading pin (pregrounding)
[3] Option D excludes option V and vice versa

Protection Degree

Condition: Female connector fitted to the unit.

IP 30: All units except those with option P, and except those with option D or V with potentiometer.

IP 20: All units fitted with option P, or with option D or V with potentiometer.

Installation Instructions

The S series AC-DC 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.

The AC-DC converters are provided with pin no. 24 (⏚), which is reliably connected with their case. For safety reasons it is essential to connect this pin with the protective earth of the supply system.

An input fuse is built-in in the connection from pins no. 30 and 32 (P~) of the unit. Since this fuse is designed to protect the unit in case of an overcurrent and does not necessarily cover all customer needs, an external fuse suitable for the application and in compliance with the local requirements might be necessary in the wiring to one or both input potentials, pins nos. 26 and 28 and/or nos. 30 and 32.

Important: Whenever the inhibit function is not in use, pin no. 18 (i) should be connected to pin no. 14 (S–/Vo1–) to enable the output(s).

Do not open the modules, or guarantee will be invalidated.

Due to high current values, all LS units provide two internally parallel connected contacts for certain paths (pins 4/6, 8/10, 26/28 and 30/32, respectively). It is recommended to connect load and supply to both female connector pins of each path in order to keep the voltage drop across the connector pins to an absolute minimum and to not overstress the connector contacts if currents are higher than approx. 8 A. The connector contacts are rated 8 A over the whole temperature range.

Make sure that there is sufficient air flow available for convection cooling. This should be verified by measuring the case temperature when the unit is installed and operated in the end-use application. The maximum specified case temperature $T_{C\,max}$ shall not be exceeded. See also: *Thermal Considerations.*

Check for hazardous voltages before altering any connections.

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.*

Cleaning Agents

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

Standards and Approvals

All AC-DC converters correspond to class I equipment. They are UL recognized according to UL 1950, UL recognized for Canada to CAN/CSA C22.2 No. 950-95 and LGA approved to IEC/EN 60950 standards.
The units have been evaluated for:

- Building in
- Basic insulation between input and case, based on 250 V AC and 400 V DC
- Double or reinforced insulation between input and output, based on 250 V AC and 400 V DC
- Basic insulation between output and case based on 200 V AC and DC
- Operational insulation between output and output
- Connecting the input to a primary or secondary circuit which is subject to a maximum transient rating of 2500 V (overvoltage category III based on a 110 V primary circuit, overvoltage category II based on a 230 V primary circuit).
- The use in a pollution degree 2 environment
- The UL 1950 recognition limits the minimum input voltage to $U_i = U_{i\,min}$ + 5 V AC = 90 V AC if the case temperature exceeds 90 °C.

The AC-DC converters are subject to manufacturing surveillance in accordance with the above mentioned UL, CSA, EN and with ISO 9001 standards.

Isolation

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

Important: Testing by applying AC voltages will result in high and dangerous leakage currents flowing through the Y-capacitors (see fig.: *Block diagram*).

Table 13: Isolation

Characteristic		Input to case	Input to output	Output to case	Output to output	Unit
Electric strength test voltage	Required according to IEC/EN 60950	1.5	3.0 [1]	–	–	kV_{rms}
		2.1	4.2 [1]	–	–	kV DC
	Actual factory test 1 s	2.8	5.6 [1]	1.4	0.14	
	AC test voltage equivalent to actual factory test	2.0	4.0 [1]	1.0	0.1	kV_{rms}
Insulation resistance at 500 V DC		>300	>300	>300	>100 [2]	MΩ

[1] In accordance with IEC/EN 60950 only subassemblies are tested in factory with this voltage.
[2] Tested at 100 V DC.

For creepage distances and clearances refer to: *Technical Information: Safety.*

Leakage Currents in AC-DC operation

Leakage currents flow due to internal leakage capacitance and RFI suppression Y-capacitors. The current values are proportional to the mains voltage and nearly proportional to the mains frequency and are specified at an input voltage of 254 V (50 Hz) where phase, neutral and protective earth are correctly connected as required for class I equipment.

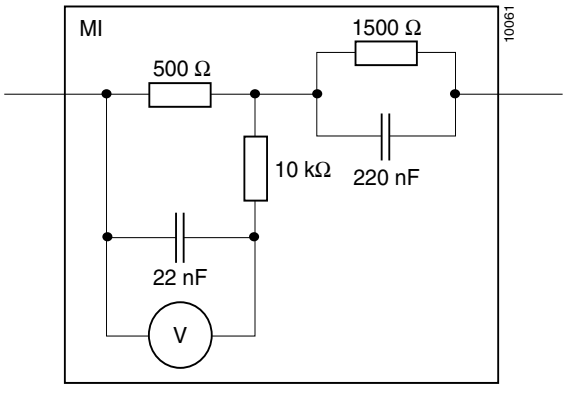


Fig. 28
Measuring instrument (MI) for earth leaking current tests according to IEC/EN 60950.

Under test conditions the leakage current flows through a measuring instrument (MI) as described in fig.: *Measuring instrument for earth leakage current tests*, which takes into account impedance and sensitivity of a person touching unearthed accessible parts. The current value is calculated by dividing the measured voltage by 500 Ω. If inputs of S-units are connected in parallel, their individual leakage currents are added.

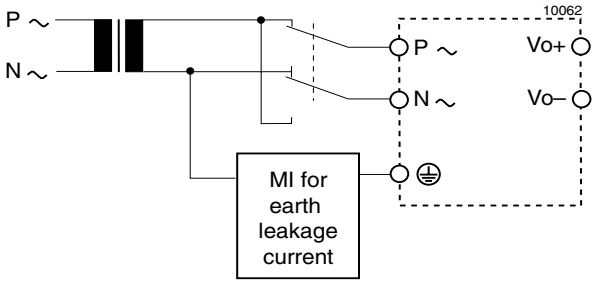


Fig. 29
Test set-up

Table 14: Leakage currents

Characteristic		Class I LS 4000...LS 5000	Unit
Maximum earth leakage current	Permissible according to IEC/EN 60950	3.5	mA
	Specified value at 254 V, 50 Hz	0.82	

Safety of operator accessible output circuit

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

The following table shows a possible installation configuration, compliance with which causes the output circuit of an S series AC-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 36 V.

However, it is the sole responsibility of the installer to assure the compliance with the relevant and applicable safety regulations. More information is given in: *Technical Information: Safety*.

Table 15: Safety concept leading to an SELV output circuit

Conditions	AC-DC converter	Installation	Result
Nominal voltage	Grade of insulation between input and output provided by the AC-DC converter	Measures to achieve the resulting safety status of the output circuit	Safety status of the AC-DC converter output circuit
Mains ≤250 V AC	Double or reinforced	Earthed case [1] and installation according to the applicable standards	SELV circuit

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

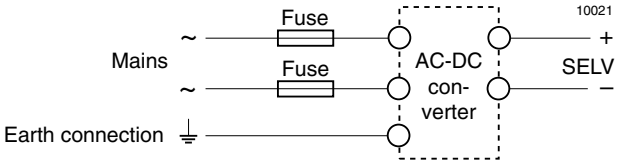


Fig. 30
Schematic safety concept. Use fuses and earth connection as per Installation Instructions and table Safety concept leading to an SELV output circuit.

Description of Options

Table 16: Survey of options

Option	Function of option	Characteristic
–9	Extended operational ambient temperature range	T_A = –40...71°C
E	Electronic inrush current limitation circuitry	Active inrush current limitation
P [1]	Potentiometer for fine adjustment of output voltage	Adjustment range +10/-60% of $U_{o\,nom}$, excludes R input
D [2]	Input and/or output undervoltage monitoring circuitry	Safe data signal output (D0...DD)
V [2 3]	Input and/or output undervoltage monitoring circuitry	ACFAIL signal according to VME specifications (V0, V2, V3)
T	Current sharing	Interconnect T-pins if paralleling outputs (5 units max.)
B1, B2	Cooling plate	Replaces standard heat sink, allowing direct chassis-mounting

[1] Function R excludes option P and vice versa
[2] Option D excludes option V and vice versa
[3] Only available if main output voltage U_{o1} = 5.1 V

-9 Extended Temperature Range

Option –9 extends the operational ambient temperature range from –25...71°C (standard) to –40...71°C. The power supplies provide full nominal output power with convection cooling. Option -9 excludes inrush current limitation by NTC.

P Potentiometer

The potentiometer provides an output voltage adjustment range of +10/–60% of $U_{o\,nom}$ and is accessible through a hole in the front cover. This feature enables compensation for voltage drops across the connector and wiring. Option P is not recommended if units are connected in parallel.

Option P excludes the R-function. With double output units both outputs are affected by the potentiometer setting (doubling the voltage setting if the outputs are in series).

If the output voltages are increased above $U_{o\,nom}$ via R-input control, option P setting, remote sensing or option T, the output current(s) should be reduced accordingly so that $P_{o\,nom}$ is not exceeded.

E Inrush Current Limitation

The converters may be supplemented by an electronic circuit (option E, replacing the standard built-in NTC) to achieve an enhanced inrush current limiting function.

Table 17: Inrush current characteristics with option E

Characteristics U_i = 230 V AC		LS typ	LS max	Unit
$I_{inr\,p}$	Peak inrush current	–	25.3	A
t_{inr}	Inrush current duration	35	50	ms

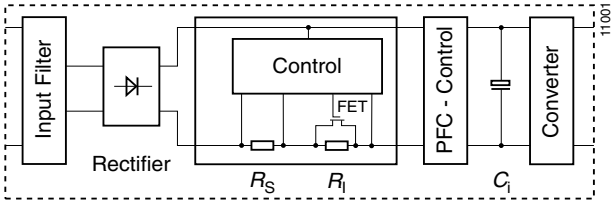


Fig. 31
Option E block diagram

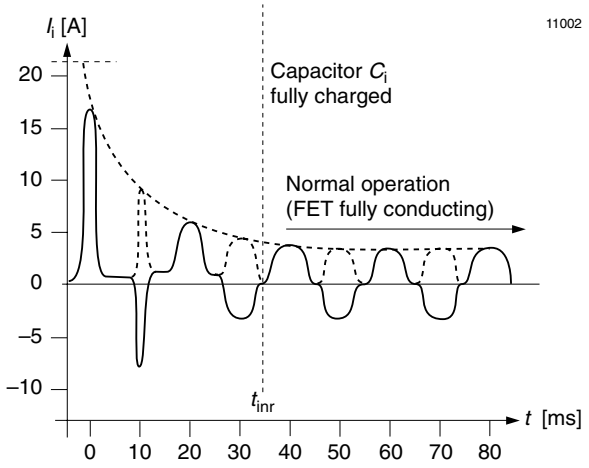


Fig. 32
Inrush current with option E, U_i = 230 V AC, $P_o = P_{o\,nom}$

Precaution:
Subsequent switch-on cycles at start-up are limited to max. 10 cycles during the first 20 seconds (cold unit) and at continuing on/off (T_C = 95°C) max. 1 cycle every 8 sec.

T Current Sharing

This option ensures that the output currents are approximately shared between all paralleled modules and increases system reliability. To use this facility, simply interconnect the T pins of all modules and make sure, that pin 14, the S– pin (S 4000) or the Vo1– pins (S 5000) are also connected together. The load leads should have equal length and cross section to ensure equal voltage drops. Not more than 5 units should be connected in parallel. If output voltage adjustment is requested we strongly recommend to use the R-input instead of option P, as with option P the required setting accuracy is difficult to achieve. The output voltages must be individually set prior to paralleling to within a tolerance of 1...2% or the R pins should be connected together.

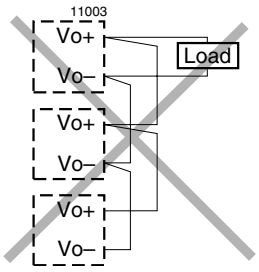
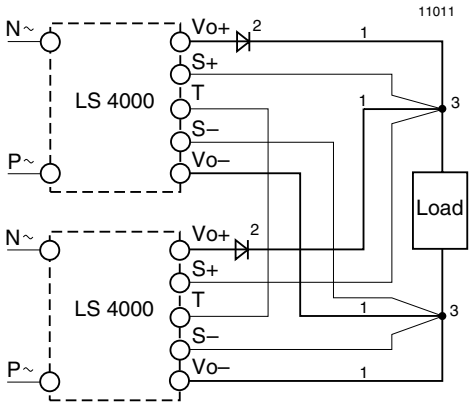


Fig. 33
An example of poor wiring for connection in parallel



[1] Leads should have equal length and cross sections and should run in the same cable loom.
[2] Diodes recommended in redundant operation only
[3] DC common point

Fig. 34
Paralleling of single output units using option T with the sense lines connected at the load

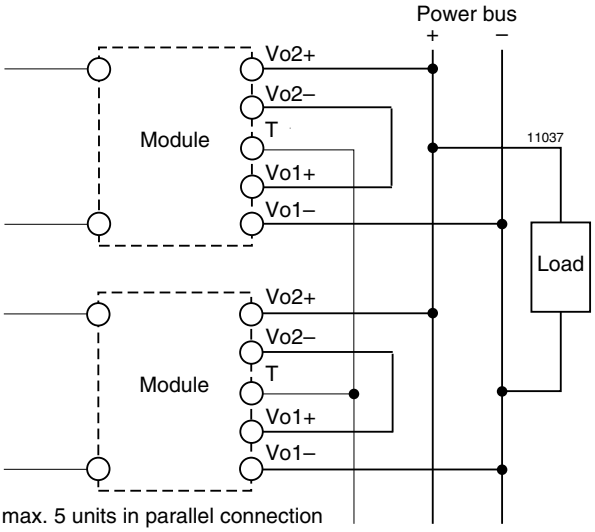


Fig. 35
Paralleling of double output units using option T with Power bus.

D Undervoltage Monitor

The input and/or output undervoltage monitoring circuit operates independently of the built-in input undervoltage lockout circuit. A logic "low" (JFET output) or "high" signal (NPN output) is generated at pin 20 as soon as one of the monitored voltages drops below the preselected threshold level U_t. The return for this signal is Vo1–. The D output recovers when the monitored voltage(s) exceed(s) $U_t + U_h$. The threshold level U_{ti} is adjusted in the factory. The threshold level U_{to} is either adjusted by a potentiometer, accessible through a hole in the front cover, or factory adjusted to a fixed value specified by the customer.

Option D exists in various versions D0...DD as shown in the following table.

Table 18: Undervoltage monitoring functions

Output type JFET	Output type NPN	Monitoring U_i	Monitoring U_{o1}	Minimum adjustment range of threshold level U_t U_{ti}	Minimum adjustment range of threshold level U_t U_{to}	Typical hysteresis U_{ho} [% of U_t] for $U_{t\,min}$...$U_{t\,max}$ U_{ho}
D1	D5	no	yes	-	3.5...40 V [1]	2.5...0.6
D2	D6	yes	no	355V DC [4]	-	-
D3	D7	yes	yes	355V DC [4]	(0.95...0.985 U_{o1}) [2]	"0"
D4	D8	no	yes	-	(0.95...0.985 U_{o1}) [2]	"0"
D0	D9	no	yes	-	3.5...40 V [3]	2.5...0.6
		yes	yes	355V DC [4]	3.5...40 V [3]	2.5...0.6
	DD	yes	yes	355V DC [4]	3.5...40 V [1]	2.5...0.6

[1] Threshold level adjustable by potentiometer
[2] Fixed value. Tracking if U_{o1} adjusted via R-input, option P or sense lines.
[3] The threshold level permanently adjusted according to customer specification ±2% at 25°C. Any value within the specified range is basically possible but causes a special type designation in addition to the standard option designations (D0/D9)!
[4] Option D monitors the boost regulator output voltage. The trigger level is adjusted in the factory to 355 V DC.

JFET output (D0…D4):

Connector pin D is internally connected via the drain-source path of a JFET (self-conducting type) to the negative potential of output 1. $U_D \leq 0.4$ V (logic low) corresponds to a monitored voltage level (U_i and/or U_{o1}) $< U_t$. The current I_D through the JFET should not exceed 2.5 mA. The JFET is protected by a 0.5 W Zener diode of 8.2 V against external overvoltages.

U_i, U_{o1} status	D output, U_D
U_i or $U_{o1} < U_t$	low, L, $U_D \leq 0.4$ V at $I_D = 2.5$ mA
U_i and $U_{o1} > U_t + U_h$	high, H, $I_D \leq 25$ µA at $U_D = 5.25$ V

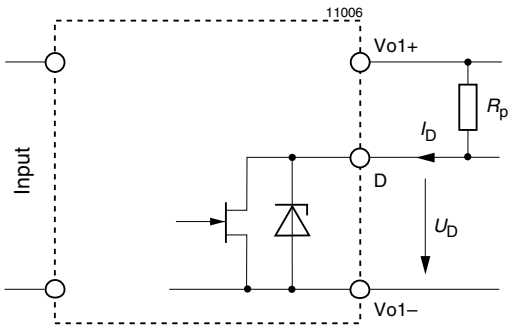


Fig. 36
Option D0...D4: JFET output, $I_D \leq 2.5$ mA

NPN output (D5...DD):

Connector pin D is internally connected via the collector-emitter path of a NPN transistor to the negative potential of output 1. $U_D < 0.4$ V (logic low) corresponds to a monitored voltage level (U_i and/or U_{o1}) $> U_t + U_h$. The current I_D through the open collector should not exceed 20 mA. The NPN output is not protected against external overvoltages. U_D should not exceed 40 V.

U_i, U_{o1} status	D output, U_D
U_i or $U_{o1} < U_t$	high, H, $I_D \leq 25$ µA at $U_D = 40$ V
U_i and $U_{o1} > U_t + U_h$	low, L, $U_D \leq 0.4$ V at $I_D = 20$ mA

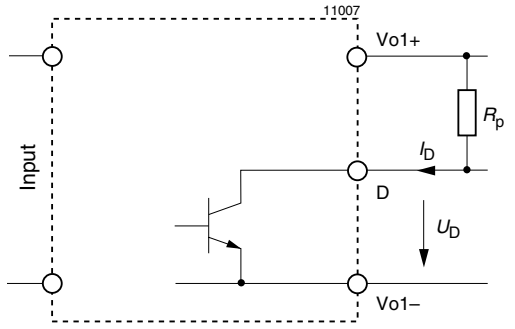


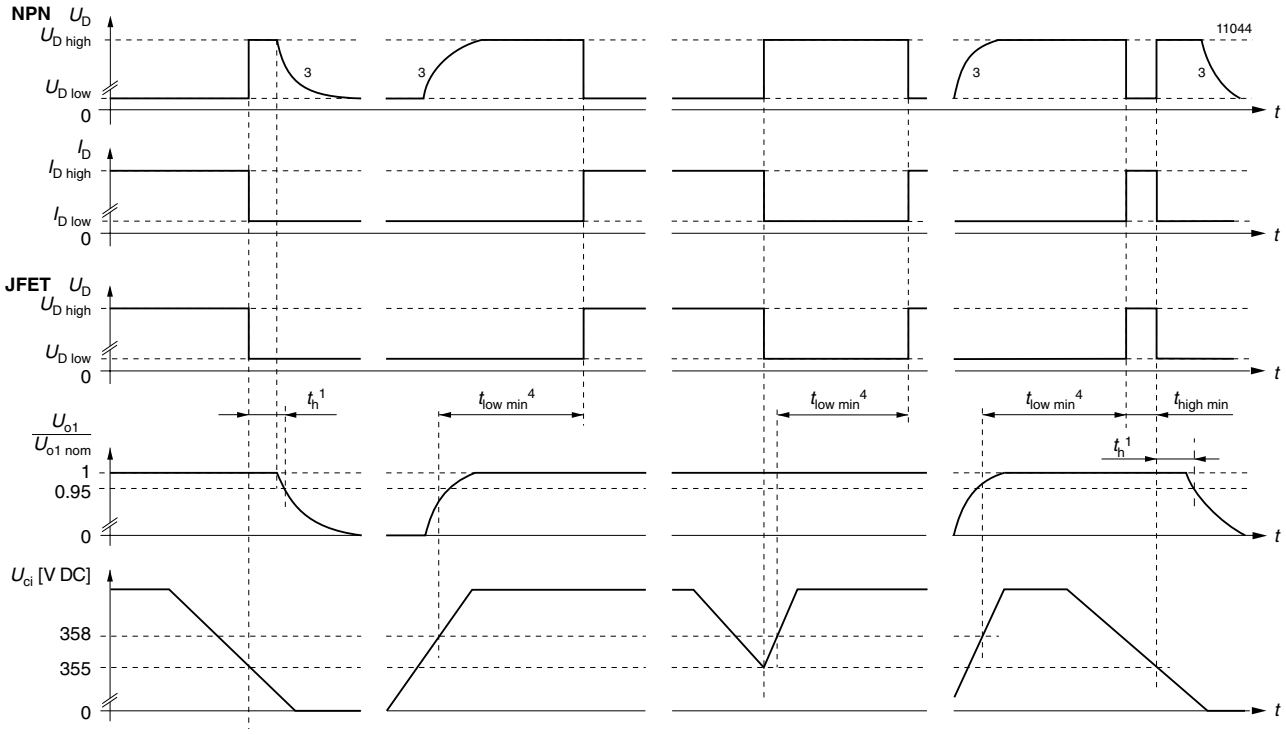
Fig. 37
Option D5...DD: NPN output, $U_{o1} \leq 40$ V, $I_D \leq 20$ mA

Table 19: D-output logic signals

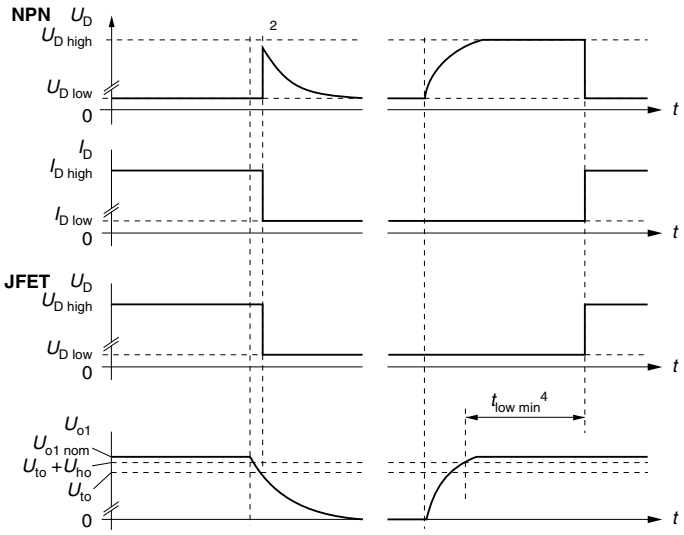
Version of D	$U_i < U_t$ resp. $U_o < U_t$	$U_i > U_t + U_h$ resp. $U_o > U_t$	Configuration
D1, D2, D3, D4, D0	low	high	JFET
D5, D6, D7, D8, D9, DD	high	low	NPN

D-signal with respect to input and output voltage versus time:

Input voltage monitoring



Output voltage monitoring



[1] Hold-up time see section Electrical Input Data.
[2] With output voltage monitoring, hold-up time $t_h = 0$.
[3] The signal will remain high if the D output is connected to an external source.
[4] $t_{low\,min}$ = 100...170 ms, typically 130 ms.

Fig. 38
Relationship between U_{ci}, U_{o1}, U_D, $U_{o1}/U_{o\,nom}$ versus time

V ACFAIL Signal (VME)

Available for units with U_{o1} = 5.1V

This option defines an undervoltage monitoring circuit for the input or input and main output voltage equivalent to option D and generates the ACFAIL signal (V signal) which conforms to the VME standard.

The low state level of the ACFAIL signal is specified at a sink current of $I_V \leq 48$ mA to $U_V \leq 0.6$ V (open-collector output of a NPN transistor). The pull-up resistor feeding the open-collector output should be placed on the VME back plane.

After the ACFAIL signal has gone low, the VME standard requires a hold-up time t_h of at least 4 ms before the 5.1 V output drops to 4.875 V when the output is fully loaded. This hold-up time t_h is provided by the internal input capacitance. See also fig.: *Hold-up Time versus Output Power*.

Table 20: Undervoltage monitor functions

V output (VME compatible)	Monitoring U_i	Monitoring U_{o1}	Minimum adjustment range of threshold level U_{ti}	Minimum adjustment range of threshold level U_{to}
V2	yes	no	355V DC [1]	–
V3	yes	yes	355V DC [1]	0.95...0.985 U_{o1} [2]

[1] Option D monitors the boost regulator output voltage. The trigger level is adjusted in the factory to 355 V DC.
[2] Fixed value between 95% and 98.5% of U_{o1}.

Option V operates independently of the built-in input undervoltage lock-out circuit. A logic "low" signal is generated at pin 20 as soon as one of the monitored voltages drops below the preselected threshold level U_t. The return for this signal is Vo1–. The V output recovers when the monitored voltage(s) exceed(s) $U_t + U_h$. The threshold level U_{ti} is adjusted in the factory to 355 V DC. The threshold level U_{to} either is adjusted during manufacture to a determined customer specified value.

V output (V2, V3):

Connector pin V is internally connected to the open collector of a NPN transistor. The emitter is connected to the negative potential of output 1. $U_V \leq 0.6$ V (logic low) corresponds to a monitored voltage level (U_i and/or U_{o1}) $< U_t$. The current I_V through the open collector should not exceed 50 mA. The NPN output is not protected against external overvoltages. U_V should not exceed 60 V.

U_i, U_{o1} status	V output, U_V
U_i or $U_{o1} < U_t$	low, L, $U_V \leq 0.6$ V at I_V = 50 mA
U_i and $U_{o1} > U_t + U_h$	high, H, $I_V \leq 25$ µA at U_V = 5.1 V

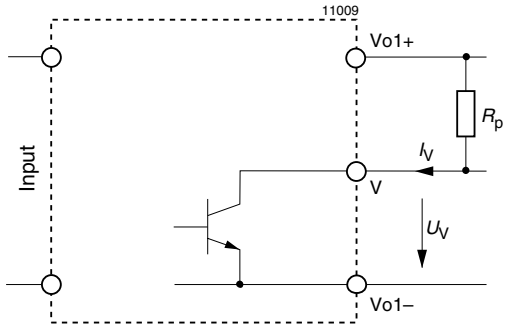
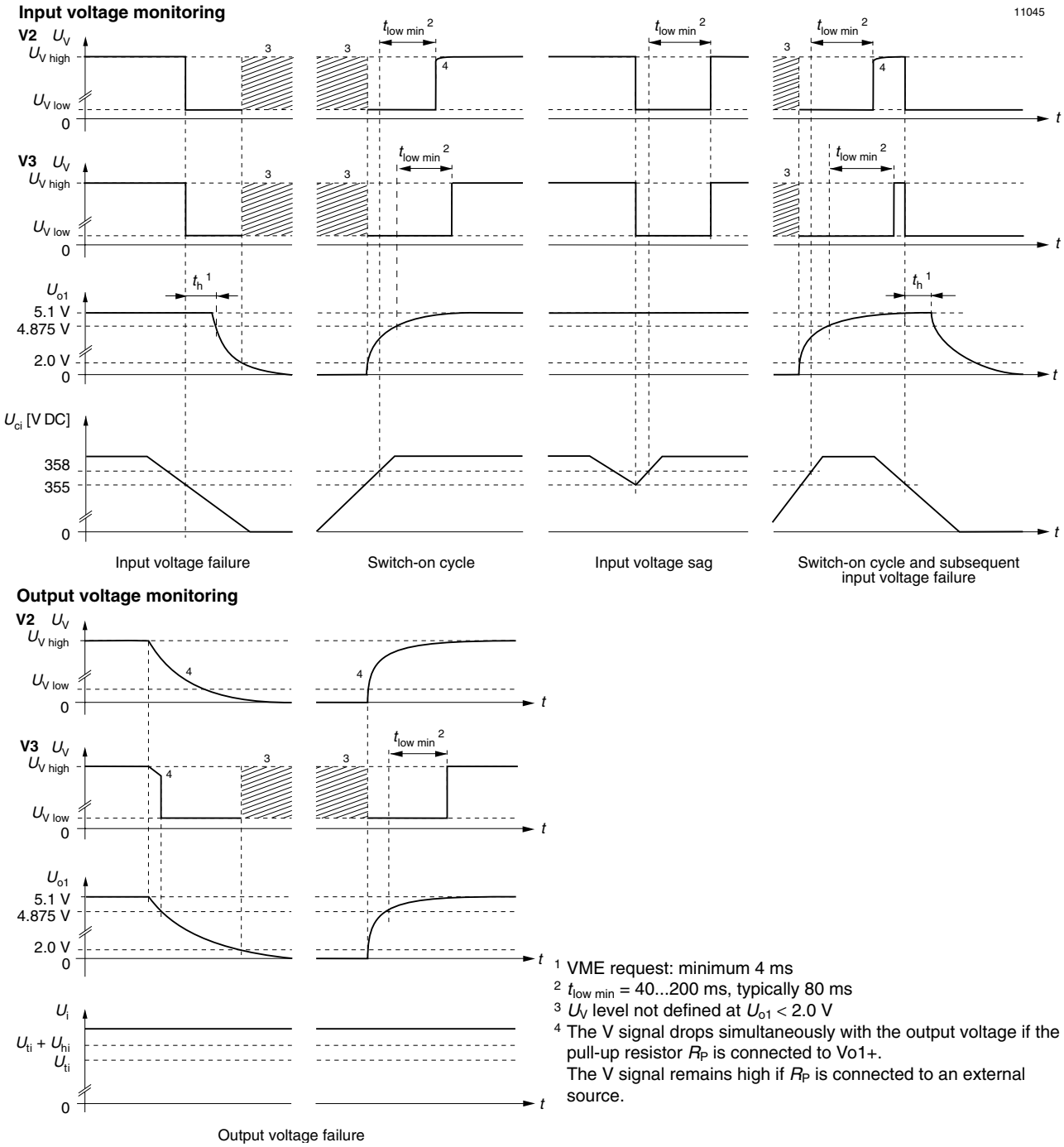


Fig. 39
Output configuration of options V2 and V3



1 VME request: minimum 4 ms
2 $t_{low\,min}$ = 40...200 ms, typically 80 ms
3 U_V level not defined at U_{o1} < 2.0 V
4 The V signal drops simultaneously with the output voltage if the pull-up resistor R_P is connected to Vo1+.
The V signal remains high if R_P is connected to an external source.

Fig. 40
Relationship between U_{ci}, U_{o1}, U_V, I_V and $U_{o1}/U_{o\,nom}$ versus time.

B1 Cooling Plate (see: *Mechanical Data*)

Where a cooling surface is available, we recommend the use of a cooling plate (option B1) instead of the standard heatsink. The mounting system should ensure sufficient cooling capacity to guarantee that the maximum case temperature $T_{C\,max}$ is not exceeded. The cooling capacity is calculated by:

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

Efficiency η see: *Type survey*.

Elongated case for 220 mm rack depth: Option B2.

Accessories

A variety of electrical and mechanical accessories are available including:

- Front panels for 19" rack mounting, Schroff and Intermas systems.
- Mating H15 connectors with screw, solder, fast-on or press-fit terminals.
- Connector retention facilities.
- Code key system for connector coding.
- Chassis mounting plates for mounting the 19" cassette to a chassis/wall where only frontal access is given.
- Universal mounting bracket for DIN-rail or chassis mounting.

For more detailed information please refer to: *Accessory Products*.



Front panels



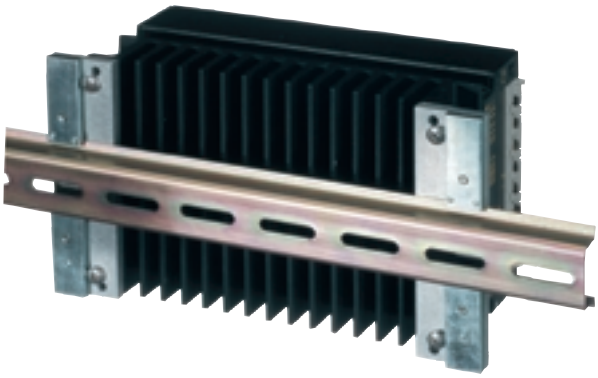
H15 female connector,
Code key system



Chassis mounting bracket S



Mounting plate,
Connector retention clips



Universal mounting bracket for DIN-rail mounting.