

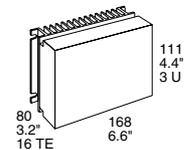
# 150 Watt DC-DC Converters

# K Series

**Input voltage ranges from 8...385 V DC  
1 or 2 outputs up to 48 V DC  
4 kV AC I/O electric strength test voltage**

- Extremely wide input voltage range
- Input over- and undervoltage lock-out
- Efficient input filter and built-in surge and transient suppression circuitry
- Fully isolated outputs
- Outputs open- and short-circuit proof
- No derating over entire operating temperature range

Safety according to IEC/EN 60950



## Summary

The K series of DC-DC converters represents a broad and flexible range of power supplies for use in advanced electronic systems. Features include 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. Certain types include an inrush current limitation preventing circuit breakers and fuses from being damaged at switch-on.

All outputs are 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 with 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.

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## Type Survey and Key Data

Non standard input configurations or special custom adaptations are available on request. See also: *Commercial Information: Inquiry Form for Customized Power Supply*.

Table 1a: Type survey AK

Output 1		Output 2		Input Voltage		Options
$U_{o\ nom}$ [V DC]	$I_{o\ nom}$ [A] <sup>2</sup>	$U_{o\ nom}$ [V DC]	$I_{o\ nom}$ [A] <sup>2</sup>	$U_{i\ min...}U_{i\ max}$ <b>8...35 V DC</b>	$\eta_{min}$ [%]	
5.1	20.0	-	-	AK 1001-7R	78	-9 E <sup>3</sup> D V <sup>6</sup> P T B1 B2
12.0	10.0	-	-	AK 1301-7R	80	
15.0	8.0	-	-	AK 1501-7R	80	
24.0	5.0	-	-	AK 1601-7R	82	
24.0 <sup>4</sup>	5.0	-	-	AK 2320-7R	78	
30.0 <sup>4</sup>	4.0	-	-	AK 2540-7R	79	
48.0 <sup>4</sup>	2.5	-	-	AK 2660-7R	79	
12.0	5.0	12.0 <sup>5</sup>	5.0	AK 2320-7R	78	
15.0	4.0	15.0 <sup>5</sup>	4.0	AK 2540-7R	79	
24.0	2.5	24.0 <sup>5</sup>	2.5	AK 2660-7R	79	

Table 1b: Type survey BK, FK, CK

Output 1		Output 2		Input Voltage Range and Efficiency <sup>1</sup>						Options
$U_{o\ nom}$ [V DC]	$I_{o\ nom}$ [A] <sup>2</sup>	$U_{o\ nom}$ [V DC]	$I_{o\ nom}$ [A] <sup>2</sup>	$U_{i\ min...}U_{i\ max}$ <b>14...70 V DC</b>	$\eta_{min}$ [%]	$U_{i\ min...}U_{i\ max}$ <b>20...100 V DC</b>	$\eta_{min}$ [%]	$U_{i\ min...}U_{i\ max}$ <b>28...140 V DC</b>	$\eta_{min}$ [%]	
5.1	25.0	-	-	BK 1001-7R	79	FK 1001-7R	80	CK 1001-7R	79	-9 E <sup>3</sup> D V <sup>6</sup> P T B1 B2
12.0	12.0	-	-	BK 1301-7R	81	FK 1301-7R	82	CK 1301-7R	82	
15.0	10.0	-	-	BK 1501-7R	82	FK 1501-7R	85	CK 1501-7R	84	
24.0	6.0	-	-	BK 1601-7R	84	FK 1601-7R	86	CK 1601-7R	86	
24.0 <sup>4</sup>	6.0	-	-	BK 2320-7R	80	FK 2320-7R	81	CK 2320-7R	80	
30.0 <sup>4</sup>	5.0	-	-	BK 2540-7R	80	FK 2540-7R	83	CK 2540-7R	82	
48.0 <sup>4</sup>	3.0	-	-	BK 2660-7R	80	FK 2660-7R	84	CK 2660-7R	84	
12.0	6.0	12.0 <sup>5</sup>	6.0	BK 2320-7R	80	FK 2320-7R	81	CK 2320-7R	80	
15.0	5.0	15.0 <sup>5</sup>	5.0	BK 2540-7R	80	FK 2540-7R	83	CK 2540-7R	82	
24.0	3.0	24.0 <sup>5</sup>	3.0	BK 2660-7R	80	FK 2660-7R	84	CK 2660-7R	84	

Table 1c: Type survey DK, EK

Output 1		Output 2		Input Voltage Range and Efficiency <sup>1</sup>				Options
$U_{o\ nom}$ [V DC]	$I_{o\ nom}$ [A] <sup>2</sup>	$U_{o\ nom}$ [V DC]	$I_{o\ nom}$ [A] <sup>2</sup>	$U_{i\ min...}U_{i\ max}$ <b>44...220 V DC</b>	$\eta_{min}$ [%]	$U_{i\ min...}U_{i\ max}$ <b>67...385 V DC</b>	$\eta_{min}$ [%]	
5.1	25.0	-	-	DK 1001-7R	79	-	-	-9 E <sup>3</sup> D V <sup>6</sup> P T B1 B2
12.0	12.0	-	-	DK 1301-7R	83	EK 1301-7R	84	
15.0	10.0	-	-	DK 1501-7R	86	EK 1501-7R	84	
24.0	6.0	-	-	DK 1601-7R	87	EK 1601-7R	84	
24.0 <sup>4</sup>	6.0	-	-	DK 2320-7R	81	EK 2320-7R	81	
30.0 <sup>4</sup>	5.0	-	-	DK 2540-7R	82	EK 2540-7R	80	
48.0 <sup>4</sup>	3.0	-	-	DK 2660-7R	85	EK 2660-7R	83	
12.0	6.0	12.0 <sup>5</sup>	6.0	DK 2320-7R	81	EK 2320-7R	81	
15.0	5.0	15.0 <sup>5</sup>	5.0	DK 2540-7R	82	EK 2540-7R	80	
24.0	3.0	24.0 <sup>5</sup>	3.0	DK 2660-7R	85	EK 2660-7R	83	

<sup>1</sup> Efficiency at  $U_{i\ nom}$  and  $I_{o\ nom}$ .

<sup>2</sup> 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 should be reduced accordingly so that  $P_{o\ nom}$  is not exceeded.

<sup>3</sup> Option E only for CK, DK, EK types.

<sup>4</sup> Series connection of output 1 and 2.

<sup>5</sup> Second output semi-regulated.

<sup>6</sup> Option V for K 1001 types only.

**Type Key**

**Type Key**

Input voltage range  $U_i$ :

- 8...35 V DC ..... A
- 14...70 V DC ..... B
- 20...100 V DC ..... F
- 28...140 V DC ..... C
- 44...220 V DC ..... D
- 67...385 V DC ..... E

Series ..... K

Number of outputs ..... 1..2

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<sup>1</sup> (24 V series connection) ..... 20
  - 15 V/15 V<sup>1</sup> (30 V series connection) ..... 40
  - 24 V/24 V<sup>1</sup> (48 V series connection) ..... 60
  - other symmetrical voltages ..... 70...99

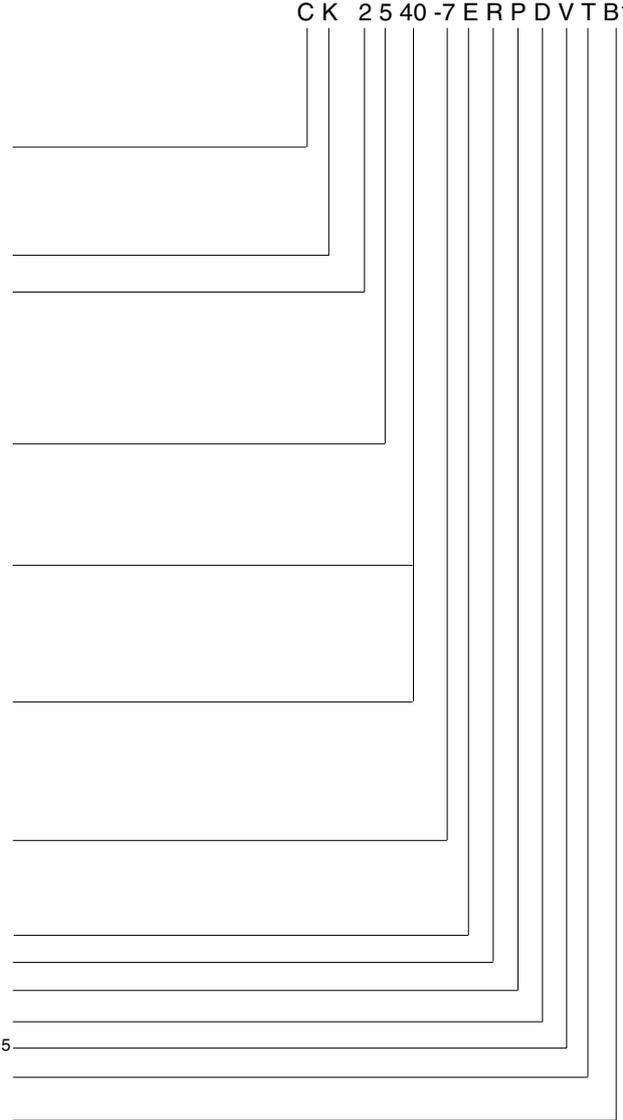
Operational ambient temperature range  $T_A$ :

- 25...71 °C ..... -7
- 40...71 °C ..... -9
- customer specific ..... -0...-6

Auxiliary functions and options:

- Inrush current limitation ..... E<sup>3</sup>
- Output voltage control input ..... R<sup>2</sup>
- Potentiometer (output voltage adjustment) ..... P<sup>2</sup>
- Save data signal (D0...DD, to be specified) ..... D<sup>4</sup>
- ACFAIL signal (V0, V2, V3, to be specified) ..... V<sup>4,5</sup>
- Current sharing ..... T
- Cooling plate standard case ..... B1
- Cooling plate for long case 220 mm ..... B2

C K 2 5 40 -7 E R P D V T B1



<sup>1</sup> External wiring of main and second output depending upon the desired output configuration (see: *R-Function for Different Output Configurations*).

<sup>2</sup> Feature R excludes option P and vice versa.

<sup>3</sup> Option E available for CK, DK and EK types.

<sup>4</sup> Option D excludes option V and vice versa.

<sup>5</sup> Option V available for K 1001 type.

Example: CK 2540-7PD3: DC-DC converter, input voltage range 28...140 V, double output, each providing 15 V/5 A, equipped with potentiometer and undervoltage monitoring option. Ambient temperature -25...71 °C.

### Functional Description

The input voltage is fed via an input fuse, an input filter, and an inrush current limiter to the input capacitor. 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 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.

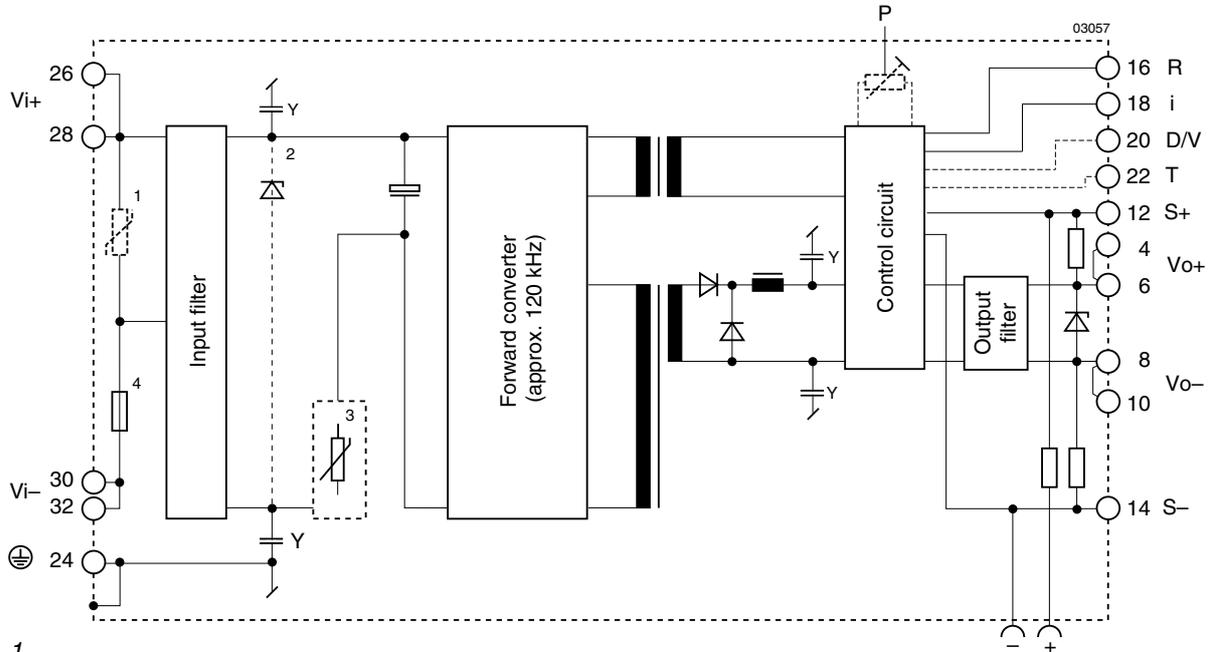


Fig. 1  
Block diagram of single output converters AK...EK 1000

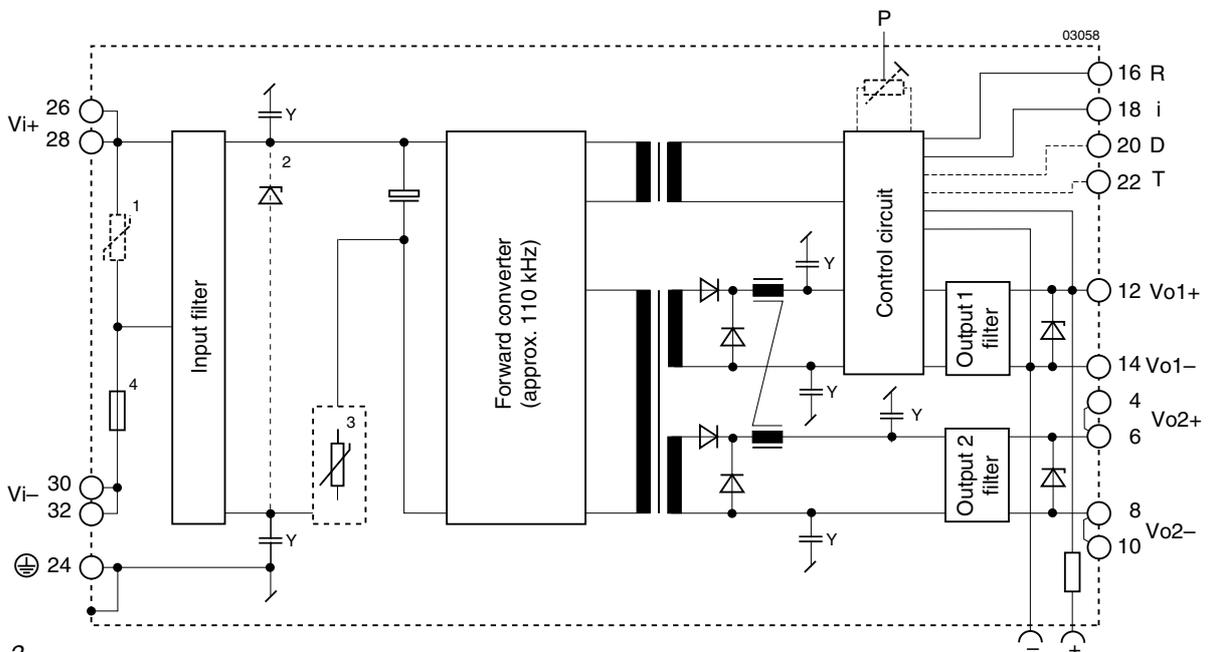


Fig. 2  
Block diagram of symmetrical double output converters AK...EK 2000

- 1 Transient suppressor (VDR) in CK, DK, EK, FK types
- 2 Transient suppressor (diode) in AK, BK, CK, FK types
- 3 Inrush current limiter in CK, DK, EK types (NTC or Opt. E), -9 versions exclude the NTC
- 4 Input fuse

## Electrical Input Data

### General Conditions

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

Table 2a: Input data

Input			AK			BK			FK			Unit				
Characteristics	Conditions	min	typ	max	min	typ	max	min	typ	max						
$U_i$	Operating input voltage	$I_o = 0 \dots I_{o\text{ nom}}$		8	35	14	70	20	100		V DC					
$U_{i\text{ nom}}$	Nominal input voltage	$T_C\text{ min} \dots T_C\text{ max}$		15			30			48						
$I_i$	Input current	$U_{i\text{ nom}}, I_{o\text{ nom}}^1$		9.0			6.0			3.75		A				
$P_{i0}$	No-load input power	$U_{i\text{ min}} \dots U_{i\text{ max}}$		2.5			2.5			2.5		W				
$P_{i\text{ inh}}$	Idle input power	unit inhibited		1.5			1.5			1.5						
$R_i$	Input resistance	$T_C = 25^\circ\text{C}$		65			100			70		m $\Omega$				
$R_{\text{NTC}}$	NTC resistance <sup>2</sup>	3			3			3								
$C_i$	Input capacitance	830			1250			300			450			1200	1800	$\mu\text{F}$
$U_{i\text{ RFI}}$	Conducted input RFI	EN 55022		A			B			B						
	Radiated input RFI	$U_{i\text{ nom}}, I_{o\text{ nom}}$		A			A			B						
$U_{i\text{ abs}}$	Input voltage limits without damage	0			40			0			80			0	100	V DC

Table 2b: Input data

Input			CK			DK			EK			Unit				
Characteristics	Conditions	min	typ	max	min	typ	max	min	typ	max						
$U_i$	Operating input voltage	$I_o = 0 \dots I_{o\text{ nom}}$		28	140	44	220	67	385		V DC					
$U_{i\text{ nom}}$	Nominal input voltage	$T_C\text{ min} \dots T_C\text{ max}$		60			110			220						
$I_i$	Input current	$U_{i\text{ nom}}, I_{o\text{ nom}}^1$		3.0			1.6			0.8		A				
$P_{i0}$	No-load input power	$U_{i\text{ min}} \dots U_{i\text{ max}}$		2.5			2.5			2.5		W				
$P_{i\text{ inh}}$	Idle input power	unit inhibited		1.5			1.5			1.5						
$R_i$	Input resistance	$T_C = 25^\circ\text{C}$		150			170			180		m $\Omega$				
$R_{\text{NTC}}$	NTC resistance <sup>2</sup>	800			1600			3200								
$C_i$	Input capacitance	660			1000			260			400			210	400	$\mu\text{F}$
$U_{i\text{ RFI}}$	Conducted input RFI	EN 55022		B			B			B						
	Radiated input RFI	$U_{i\text{ nom}}, I_{o\text{ nom}}$		B			B			B						
$U_{i\text{ abs}}$	Input voltage limits without damage	0			154			0			400 <sup>4</sup>			0	400	V DC

<sup>1</sup> With double output modules, both outputs loaded with  $I_{o\text{ nom}}$ .

<sup>2</sup> 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.

<sup>3</sup> AK, BK and FK types have no NTC (inrush current limiter) fitted.

<sup>4</sup> 1 s max., duty cycle 1% max.

### Input Transient Protection

A suppressor diode or a VDR (depending upon the input voltage range) together with the input fuse and a symmetrical input filter form an effective protection against high input transient voltages which typically occur in most installations, but especially in battery driven mobile applications.

Nominal battery voltages in use are: 12, 24, 36, 48, 60, 72, 110 and 220 V. In most cases each nominal value is specified in a tolerance of  $-30\% \dots +25\%$ .

In certain applications, surges according to RIA 12 are specified in addition to those defined in IEC 571-1. The power supply must not switch off during these surges and since their energy can practically not be absorbed an ex-

tremely wide input range is required. The EK input range for 110 V batteries has been designed and tested to meet this requirement.

### Inrush Current Limitation

The CK, DK, EK modules 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*.

**Input Fuse**

A fuse mounted inside the converter protects the module against severe defects. 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
AK <sup>1</sup>	fast-blow	Little fuse 314 30.0 A, 125 V
BK <sup>1</sup>	fast-blow	Little fuse 314 25.0 A, 125 V
CK <sup>2</sup>	slow-blow	SPT 12.5 A, 250 V
DK <sup>2</sup>	slow-blow	SPT 8 A, 250 V
EK <sup>2</sup>	slow-blow	SPT 4 A, 250 V
FK <sup>2</sup>	slow-blow	SPT 16 A, 250 V

<sup>1</sup> Fuse size 6.3 × 32 mm    <sup>2</sup> Fuse size 5 × 20 mm

**Static Input Current Characteristic**

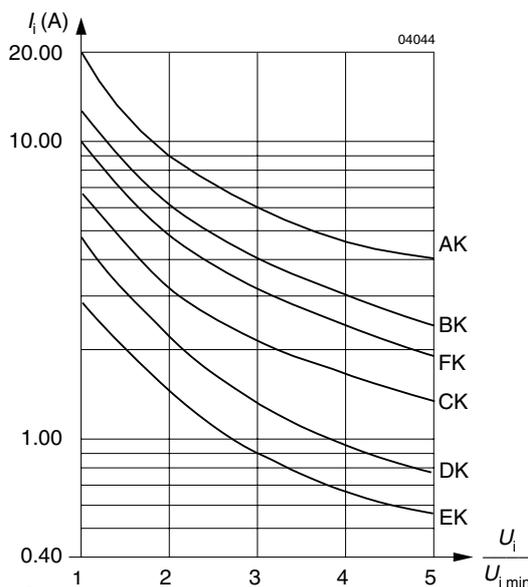


Fig. 3 Typical input current versus relative input voltage

**Inrush Current Peak Value**

The inrush current peak value (initial switch-on cycle) can be determined by following calculation: (See also: *Input Inrush Current Characteristic*)

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

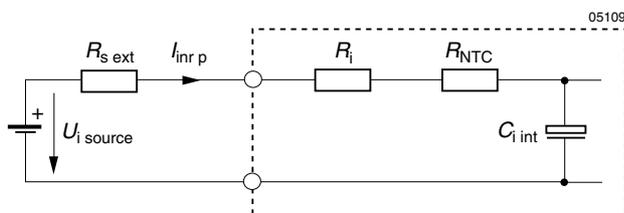


Fig. 4 Equivalent circuit for input impedance

**Reverse Polarity**

The units are not protected against reverse polarity at the input to avoid unwanted power losses and may be damaged.

**Input Inrush Current Characteristic**

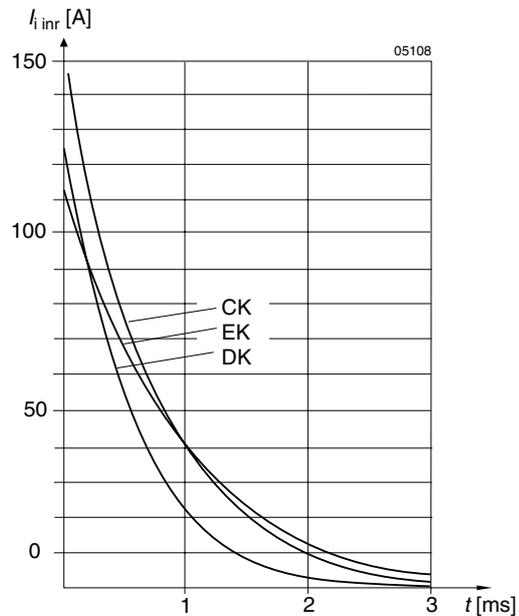


Fig. 5 Typical inrush current versus time at  $U_{i max}$ ,  $R_{ext} = 0$ . For AK, BK and FK as well as for application related values use the formula given in Inrush Current Peak Value to get realistic results.

**Input Under-/Overvoltage Lock-out**

If the input voltage remains below approx.  $0.8 U_{i min}$  or exceeds approx.  $1.1 U_{i max}$ , 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*).

**Hold-up Time versus relative Input Voltage**

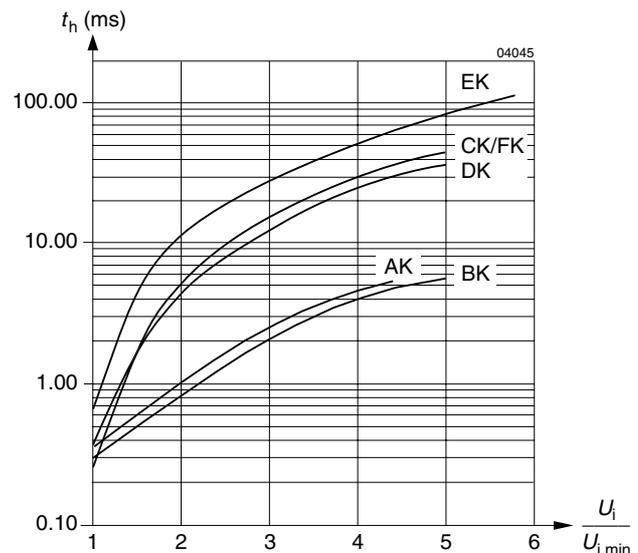


Fig. 6 Typical hold-up time  $t_h$  versus relative input voltage  $U_i/U_{i min}$ . The DC-DC converters require an external series diode in the input path if other loads are connected to the same input supply lines.

## Electrical Output Data

### General Conditions

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

Table 4a: Output data single output modules AK/BK

Output			AK/BK 1001 5.1 V		AK/BK 1301 12.0 V		AK/BK 1501 15.0 V		AK/BK 1601 24.0 V		Unit		
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ		max	
$U_o$	Output voltage		$U_{i\text{ nom}}, I_{o\text{ nom}}$		5.07	5.13	11.93	12.07	14.91	15.09	23.86	24.14	V
$U_{oP}$	Overvoltage protection (suppressor diode)				7.6		21		26.5		43.5		
$I_{o\text{ nom}}$	Output current <sup>1</sup>		$U_{i\text{ min}} \dots U_{i\text{ max}}$ $T_C\text{ min} \dots T_C\text{ max}$		20.0/25.0		10.0/12.0		8.0/10.0		5.0/6.0		A
$I_{oL}$	Output current limit <sup>4</sup>		$U_{i\text{ min}} \dots U_{i\text{ max}}$		21/26		10.2/12.2		8.2/10.2		5.2/6.2		
$u_o^7$	Output voltage noise	Switching freq.	$U_{i\text{ nom}}, I_{o\text{ nom}}$		10		5		5		5		mV <sub>pp</sub>
		Total	IEC/EN 61204 BW = 20 MHz		60		40		30		50		
$\Delta U_{ou}$	Static line regulation		$U_{i\text{ min}} \dots U_{i\text{ nom}}$ $U_{i\text{ nom}} \dots U_{i\text{ max}}$ $I_{o\text{ nom}}$		$\pm 15$		$\pm 25$		$\pm 30$		$\pm 30$		mV
$\Delta U_{o1}$	Static load regulation		$U_{i\text{ nom}}, I_o =$ $(0.1 \dots 1) I_{o\text{ nom}}$		20		25		30		40		
$u_{od}^5$	Dynamic load regulation	Voltage deviation	$U_{i\text{ nom}}, I_o =$ $I_{o\text{ nom}} \leftrightarrow 1/2 I_{o\text{ nom}}$		$\pm 220$		$\pm 110$		$\pm 150$		$\pm 130$		
$t_d^5$		Recovery time	IEC/EN 61204		0.6		0.6		0.5		1		ms
$\alpha_{Uo}$	Temperature coefficient of output voltage <sup>6</sup>		$T_C\text{ min} \dots T_C\text{ max}$ $0 \dots I_{o\text{ nom}}$		–0.2		–1		–1		–1		mV/K

<sup>1</sup> If the output voltages are increased above  $U_{o\text{ nom}}$  through R-input control, option P setting, remote sensing or option T, the output current should be reduced accordingly so that  $P_{o\text{ nom}}$  is not exceeded.

<sup>4</sup> See: *Output voltage regulation of single output units.*

<sup>5</sup> See: *Dynamic load regulation of  $U_{o1}$ .*

<sup>6</sup> Negative temperature coefficient (0...–3 mV/cell and K) available on request

<sup>7</sup> 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 AK/BK

Output (Outputs connected in Series)			AK/BK 2320 24 V (2 × 12 V)			AK/BK 2540 30 V (2 × 15 V)			AK/BK 2660 48 V (2 × 24 V)			Unit
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	
$U_o$	Output voltage	$U_{i\ nom}, I_{o\ nom}$	24.0 <sup>2</sup>			30.0 <sup>2</sup>			48.0 <sup>2</sup>			V
$U_{o\ P}$	Overvoltage protection (suppressor diode)		38			48			74			
$I_{o\ nom}$	Output current <sup>1</sup>	$U_{i\ min} \dots U_{i\ max}$ $T_C\ min \dots T_C\ max$	5.0/6.0			4.0/5.0			2.5/3.0			A
$I_{o\ L}$	Output current limit <sup>4</sup>	$U_{i\ min} \dots U_{i\ max}$	5.2/6.2			4.2/5.2			2.7/3.2			
$u_o$ <sup>7</sup>	Output voltage noise <sup>3</sup>	Switching freq.	10			5			5			mV <sub>pp</sub>
		Total	60			60			70			
$\Delta U_{o\ u}$	Static line regulation	$U_{i\ min} \dots U_{i\ nom}$ $U_{i\ nom} \dots U_{i\ max}$ $I_{o\ nom}$	±15			±15			±20			mV
$\Delta U_{o\ l}$	Static load regulation	$U_{i\ nom}, I_o =$ (0.1 ... 1) $I_{o\ nom}$	25			25			35			
$u_{o\ d}$ <sup>5</sup>	Dynamic load regulation	Voltage deviation	±180			±160			±100			ms
$t_d$ <sup>5</sup>		Recovery time	0.3			0.2			0.2			
$\alpha_{U_o}$	Temperature coefficient of output voltage <sup>6</sup>	$T_C\ min \dots T_C\ max$ 0... $I_{o\ nom}$	-2			-2			-2			mV/K

<sup>1</sup> If the output voltages are increased above  $U_{o\ nom}$  through R-input control, option P setting, remote sensing or option T, the output current should be reduced accordingly so that  $P_{o\ nom}$  is not exceeded.

<sup>2</sup> Series connection for  $U_{o\ nom} = 24\ V, 30\ V$  or  $48\ V$ , see: *R-Function for Different Output Configurations*.

<sup>3</sup> Shortest possible wiring for series connection at the connector.

<sup>4</sup> See: *Output voltage regulation of single output units*.

<sup>5</sup> See: *Dynamic load regulation of  $U_{o1}$  and  $U_{o2}$* .

<sup>6</sup> Negative temperature coefficient (0...-3 mV/cell and K) available on request.

<sup>7</sup> 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 AK/BK

Output (Outputs independently loaded) <sup>1</sup>			AK/BK 2320 12 V/12 V				AK/BK 2540 15 V/15 V				Unit				
Characteristics		Conditions	Output 1			Output 2			Output 1			Output 2			
			min	typ	max	min	typ	max	min	typ		max	min	typ	max
$U_o$	Output voltage		$U_{i \text{ nom}}, I_{o \text{ nom}}^2$		11.93	12.07	11.82	12.18	14.91	15.09	14.78	15.23	V		
$U_{o \text{ P}}$	Overvoltage protection (suppressor diode)				19			19			24				
$I_{o \text{ nom}}$	Output current <sup>3</sup>		$U_{i \text{ min}} \dots U_{i \text{ max}}$ $T_{C \text{ min}} \dots T_{C \text{ max}}$		5.0/6.0			5.0/6.0			4.0/5.0			A	
$I_{o \text{ L}}$	Output current limit <sup>4</sup>		$U_{i \text{ min}} \dots U_{i \text{ max}}$		5.2/6.2			5.2/6.2			4.2/5.2				
$u_{o \text{ }^9}$	Output voltage noise	Switching freq.	$U_{i \text{ nom}}, I_{o \text{ nom}}$ IEC/EN 61204 BW = 20 MHz		10			10			10			mV <sub>pp</sub>	
		Total			50			20			50				20
$\Delta U_{o \text{ u}}$	Static line regulation		$U_{i \text{ min}} \dots U_{i \text{ nom}}$ $U_{i \text{ nom}} \dots U_{i \text{ max}}$ $I_{o \text{ nom}}$		±30			±30			±30			mV	
$\Delta U_{o \text{ l}}$	Static load regulation		$U_{i \text{ nom}}, I_o =$ (0.1...1) $I_{o \text{ nom}}^5$		50			8			50			8	
$u_{o \text{ d}}^6$	Dynamic load regulation	Voltage deviation	$U_{i \text{ nom}}, I_o =$ $I_{o \text{ nom}} \leftrightarrow 1/2 I_{o \text{ nom}}$ IEC/EN 61204		±80			±80							
$t_d^6$		Recovery time			0.2			0.2						ms	
$\alpha_{U_o}$	Temperature coefficient of output voltage <sup>7</sup>		$T_{C \text{ min}} \dots T_{C \text{ max}}$ 0... $I_{o \text{ nom}}$		-1			-1						mV/K	

Table 4d: Output data double output modules AK/BK

Output (Outputs independently loaded) <sup>1</sup>			AK/BK 2660 24 V/24 V				Unit			
Characteristics		Conditions	Output 1			Output 2				
			min	typ	max	min		typ	max	
$U_o$	Output voltage		$U_{i \text{ nom}}, I_{o \text{ nom}}^2$		23.86	24.14	23.64	24.36	V	
$U_{o \text{ P}}$	Overvoltage protection (suppressor diode)				37			37		
$I_{o \text{ nom}}$	Output current <sup>3</sup>		$U_{i \text{ min}} \dots U_{i \text{ max}}$ $T_{C \text{ min}} \dots T_{C \text{ max}}$		2.5/3.0			2.5/3.0		A
$I_{o \text{ L}}$	Output current limit <sup>4</sup>		$U_{i \text{ min}} \dots U_{i \text{ max}}$		2.7/3.2			2.7/3.2		
$u_{o \text{ }^9}$	Output voltage noise	Switching freq.	$U_{i \text{ nom}}, I_{o \text{ nom}}$ IEC/EN 61204 BW = 20 MHz		5			5		mV <sub>pp</sub>
		Total			60			30		
$\Delta U_{o \text{ u}}$	Static line regulation		$U_{i \text{ min}} \dots U_{i \text{ nom}}$ $U_{i \text{ nom}} \dots U_{i \text{ max}}$ $I_{o \text{ nom}}$		±40			±40		mV
$\Delta U_{o \text{ l}}$	Static load regulation		$U_{i \text{ nom}}, I_o =$ (0.1...1) $I_{o \text{ nom}}^5$		70			8		
$u_{o \text{ d}}^6$	Dynamic load regulation	Voltage deviation	$U_{i \text{ nom}}, I_o =$ $I_{o \text{ nom}} \leftrightarrow 1/2 I_{o \text{ nom}}$ IEC/EN 61204		±50					
$t_d^6$		Recovery time			0.2					ms
$\alpha_{U_o}$	Temperature coefficient of output voltage <sup>7</sup>		$T_{C \text{ min}} \dots T_{C \text{ max}}$ 0... $I_{o \text{ nom}}$		-1					mV/K

<sup>1</sup> Depending upon the desired output configuration the wiring should be made as shown in: *R-Function for Different Output Configurations*.

<sup>2</sup> Same conditions for both outputs.

<sup>3</sup> If the output voltages are increased above  $U_{o \text{ nom}}$  via R-input control, option P setting, remote sensing or option T, the output currents should be reduced accordingly so that  $P_{o \text{ nom}}$  is not exceeded.

<sup>4</sup> See: *Output voltage regulation of single output units*.

<sup>5</sup> Condition for specified output.

Other output loaded with constant current  $I_o = I_{o \text{ nom}}$

<sup>6</sup> See: *Dynamic load regulation of  $U_{o1}$  and  $U_{o2}$* .

<sup>7</sup> Negative temperature coefficient (0...-3 mV/cell and K) available on request.

<sup>8</sup> See: *Output Voltage Regulation of Double Output Modules*.

<sup>9</sup> 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 4e: Output data single output modules CK...EK

Output			CK...DK 1001 5.1 V			CK...EK 1301 12.0 V			CK...EK 1501 15.0 V			CK...EK 1601 24.0 V			Unit
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	min	typ	max	
$U_o$	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	
$U_{o\ P}$	Overvoltage protection (suppressor diode)					7.6		21		26.5		43.5			
$I_{o\ nom}$	Output current <sup>1</sup>		$U_{i\ min...}U_{i\ max}$ $T_{C\ min...}T_{C\ max}$			25.0		12.0		10.0		6.0		A	
$I_{o\ L}$	Output current limit <sup>4</sup>		$U_{i\ min...}U_{i\ max}$			26		12.2		10.2		6.2			
$u_o^7$	Output voltage noise	Switching freq.	$U_{i\ nom}, I_{o\ nom}$ IEC/EN 61204 BW = 20 MHz			10		5		5		5		mV <sub>pp</sub>	
		Total				50		40		30		50			
$\Delta U_{o\ u}$	Static line regulation		$U_{i\ min...}U_{i\ nom}$ $U_{i\ nom...}U_{i\ max}$ $I_{o\ nom}$				±15		±25		±30		±30	mV	
$\Delta U_{o\ l}$	Static load regulation		$U_{i\ nom}, I_o =$ (0.1...1) $I_{o\ nom}$				20		25		30		40		
$u_{o\ d}^5$	Dynamic load regulation	Voltage deviation	$U_{i\ nom}, I_o =$ $I_{o\ nom} \leftrightarrow 1/2 I_{o\ nom}$ IEC/EN 61204			±100		±100		±100		±80			
$t_d^5$		Recovery time				0.3		0.5		0.4		0.3		ms	
$\alpha_{U_o}$	Temperature coefficient of output voltage <sup>6</sup>		$T_{C\ min...}T_{C\ max}$ 0... $I_{o\ nom}$			-1		-1		-1		-2		mV/K	

Table 4f: Output data double output modules CK...EK

Output (Outputs connected in Series)			CK...EK 2320 24 V (2 × 12 V)			CK...EK 2540 30 V (2 × 15 V)			CK...EK 2660 48 V (2 × 24 V)			Unit
Characteristics		Conditions	min	typ	max	min	typ	max	min	typ	max	
$U_o$	Output voltage		$U_{i\ nom}, I_{o\ nom}$			24.0 <sup>2</sup>		30.0 <sup>2</sup>		48.0 <sup>2</sup>		V
$U_{o\ P}$	Overvoltage protection (suppressor diode)					38		48		74		
$I_{o\ nom}$	Output current <sup>1</sup>		$U_{i\ min...}U_{i\ max}$ $T_{C\ min...}T_{C\ max}$			6.0		5.0		3.0		A
$I_{o\ L}$	Output current limit <sup>4</sup>		$U_{i\ min...}U_{i\ max}$			6.2		5.2		3.2		
$u_o^7$	Output voltage noise <sup>3</sup>	Switching freq.	$U_{i\ nom}, I_{o\ nom}$ IEC/EN 61204 BW = 20 MHz			15		15		20		mV <sub>pp</sub>
		Total				100		120		120		
$\Delta U_{o\ u}$	Static line regulation		$U_{i\ min...}U_{i\ nom}$ $U_{i\ nom...}U_{i\ max}$ $I_{o\ nom}$			±40		±30		±50		mV
$\Delta U_{o\ l}$	Static load regulation		$U_{i\ nom}, I_o =$ (0.1...1) $I_{o\ nom}$			40		30		40		
$u_{o\ d}^5$	Dynamic load regulation	Voltage deviation	$U_{i\ nom}, I_o =$ $I_{o\ nom} \leftrightarrow 1/2 I_{o\ nom}$ IEC/EN 61204			±100		±100		±100		
$t_d^5$		Recovery time				0.3		0.5		0.4		ms
$\alpha_{U_o}$	Temperature coefficient of output voltage <sup>6</sup>		$T_{C\ min...}T_{C\ max}$ 0... $I_{o\ nom}$			-2.2		-2.2		-2.6		mV/K

<sup>1</sup> If the output voltages are increased above  $U_{o\ nom}$  through R-input control, option P setting, remote sensing or option T, the output current should be reduced accordingly so that  $P_{o\ nom}$  is not exceeded.

<sup>2</sup> Series connection for  $U_{o\ nom} = 24\ V, 30\ V$  or  $48\ V$ , see: *R-Function for Different Output Configurations*.

<sup>3</sup> Shortest possible wiring for series connection at the connector.

<sup>4</sup> See: *Output voltage regulation of single output units*.

<sup>5</sup> See: *Dynamic load regulation of  $U_{o1}$  and  $U_{o2}$* .

<sup>6</sup> Negative temperature coefficient (0...-3 mV/cell and K) available on request

<sup>7</sup> 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 4g: Output data double output modules CK...EK

Output (Outputs independently loaded) <sup>1</sup>			CK...EK 2320 12 V/12 V			CK...EK 2540 15 V/15 V			Unit		
Characteristics		Conditions	Output 1		Output 2		Output 1			Output 2	
			min	typ	max	min	typ	max		min	typ
$U_o$	Output voltage	$U_{i\text{ nom}}, I_{o\text{ nom}}^2$	11.93	12.07	11.82	12.18	14.91	15.09	14.78	15.22	V
$U_{oP}$	Overvoltage protection (suppressor diode)	Failure in control circuit	19		19		24		24		
$I_{o\text{ nom}}$	Output current <sup>3</sup>	$U_{i\text{ min}}...U_{i\text{ max}}$ $T_{C\text{ min}}...T_{C\text{ max}}$	6.0		6.0		5.0		5.0		A
$I_{oL}$	Output current limit <sup>4</sup>	$U_{i\text{ min}}...U_{i\text{ max}}$	6.2		6.2		5.2		5.2		
$u_o^9$	Output voltage noise	Switching freq.	5		5		5		5		mV <sub>pp</sub>
		Total	75		25		100		25		
$\Delta U_{oU}$	Static line regulation	$U_{i\text{ min}}...U_{i\text{ nom}}$ $U_{i\text{ nom}}...U_{i\text{ max}}$ $I_{o\text{ nom}}$	±30		±40		±30		±40		mV
$\Delta U_{oI}$	Static load regulation	$U_{i\text{ nom}}, I_o =$ $(0.1...1) I_{o\text{ nom}}^5$	100		8		100		8		
$u_{o d}^6$	Dynamic load regulation	Voltage deviation	±100				±80				
$t_d^6$		Recovery time	0.3				0.2				ms
$\alpha_{Uo}$	Temperature coefficient of output voltage <sup>7</sup>	$T_{C\text{ min}}...T_{C\text{ max}}$ $0...I_{o\text{ nom}}$	-1.1				-1.1				mV/K

Table 4h: Output data double output modules CK...EK

Output (Outputs independently loaded) <sup>1</sup>			CK...EK 2660 24 V/24 V			Unit	
Characteristics		Conditions	Output 1		Output 2		
			min	typ	max		min
$U_o$	Output voltage	$U_{i\text{ nom}}, I_{o\text{ nom}}^2$	23.86	24.14	23.64	24.36	V
$U_{oP}$	Overvoltage protection (suppressor diode)		37		37		
$I_{o\text{ nom}}$	Output current <sup>3</sup>	$U_{i\text{ min}}...U_{i\text{ max}}$ $T_{C\text{ min}}...T_{C\text{ max}}$	3.0		3.0		A
$I_{oL}$	Output current limit <sup>4</sup>	$U_{i\text{ min}}...U_{i\text{ max}}$	3.2		3.2		
$u_o^9$	Output voltage noise	Switching freq.	5		5		mV <sub>pp</sub>
		Total	100		25		
$\Delta U_{oU}$	Static line regulation	$U_{i\text{ min}}...U_{i\text{ nom}}$ $U_{i\text{ nom}}...U_{i\text{ max}}$ $I_{o\text{ nom}}$	±30		±50		mV
$\Delta U_{oI}$	Static load regulation	$U_{i\text{ nom}}, I_o =$ $(0.1...1) I_{o\text{ nom}}^5$	50		8		
$u_{o d}^6$	Dynamic load regulation	Voltage deviation	±50				
$t_d^6$		Recovery time	0.2				ms
$\alpha_{Uo}$	Temperature coefficient of output voltage <sup>7</sup>	$T_{C\text{ min}}...T_{C\text{ max}}$ $0...I_{o\text{ nom}}$	-1.3				mV/K

<sup>1</sup> Depending upon the desired output configuration the wiring should be made as shown in: *R-Function for Different Output Configurations*.

<sup>2</sup> Same conditions for both outputs.

<sup>3</sup> If the output voltages are increased above  $U_{o\text{ nom}}$  via R-input control, option P setting, remote sensing or option T, the output currents should be reduced accordingly so that  $P_{o\text{ nom}}$  is not exceeded.

<sup>4</sup> See: *Output voltage regulation of single output units*.

<sup>5</sup> Condition for specified output.

Other output loaded with constant current  $I_o = I_{o\text{ nom}}$ .

<sup>6</sup> See: *Dynamic load regulation of  $U_{o1}$  and  $U_{o2}$* .

<sup>7</sup> Negative temperature coefficient (0...-3 mV/cell and K) available on request.

<sup>8</sup> See: *Output Voltage Regulation of Double Output Modules*.

<sup>9</sup> 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*.)

### 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.

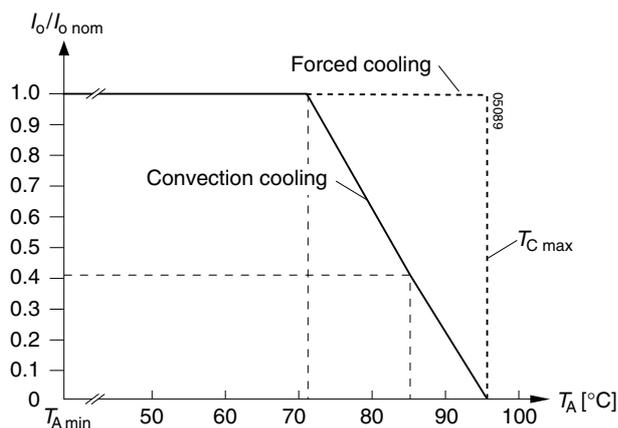


Fig. 7  
Output current derating versus temperature for -7 and -9 units.

### 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 overvoltages which could occur due to a failure of the internal control circuit. Voltage suppressor diodes (which under worst case condition may become a short circuit) provide the required protection. The suppressor diodes are not designed to withstand externally applied overvoltages. Overload at any of the outputs will cause a shut-down of all 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.

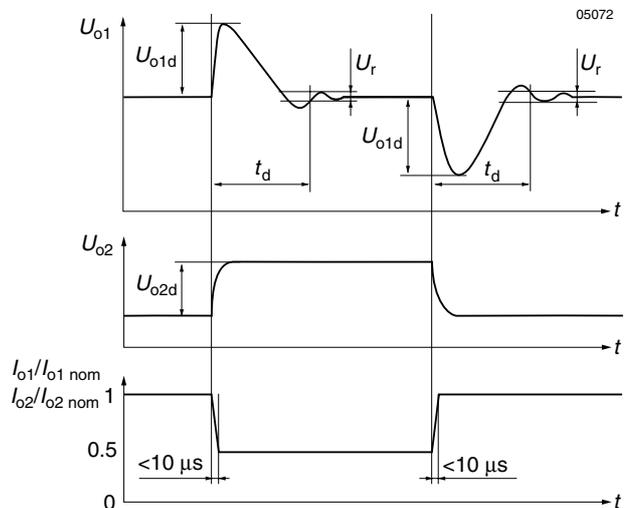


Fig. 8  
Typical dynamic load regulation of  $U_{o1}$  and  $U_{o2}$

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

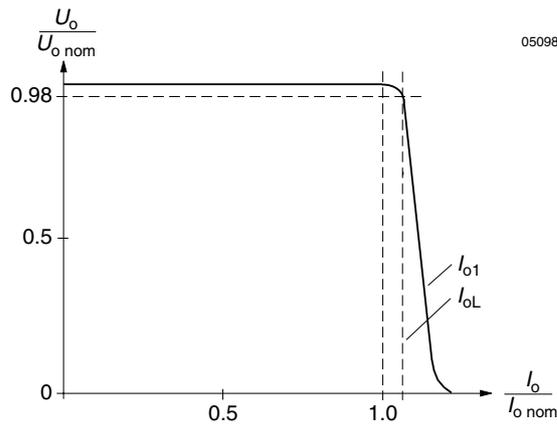


Fig. 9  
 $U_{o1}$  vs.  $I_{o1}$  (typ.) of single output units AK...EK

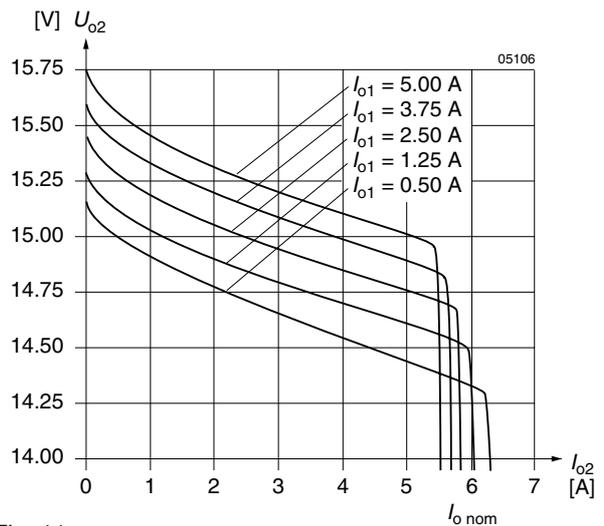


Fig. 11  
 AK...EK 2540:  $\Delta U_{o2}$  (typ.) vs.  $I_{o2}$  with different  $I_{o1}$

**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  $\pm 5\%$  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  $\pm 1\%$  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 K 2000 module connected in parallel will behave like the output of a K 1000 module; the paralleled output is fully regulated. No precautions are necessary in using the R-input and the test sockets.

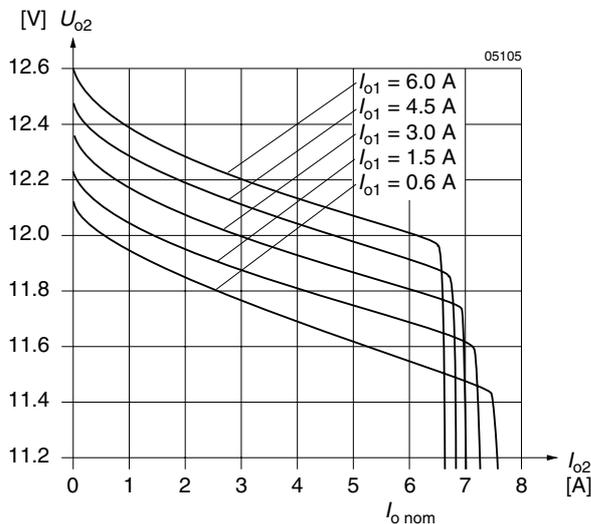


Fig. 10  
 AK...EK 2320:  $\Delta U_{o2}$  (typ.) vs.  $I_{o2}$  with different  $I_{o1}$

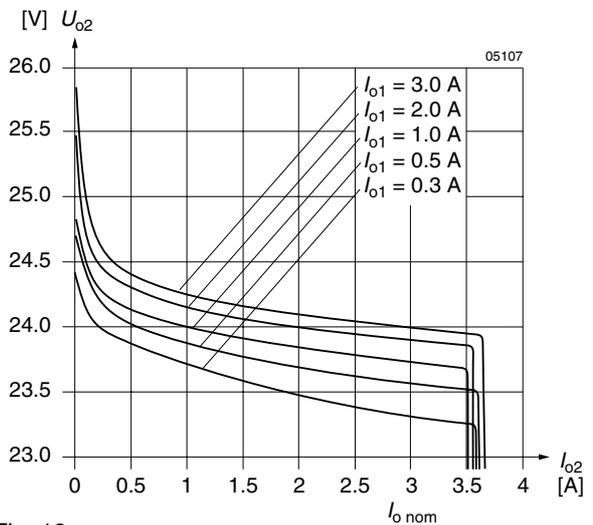


Fig. 12  
 AK...EK 2660:  $\Delta U_{o2}$  (typ.) vs.  $I_{o2}$  with different  $I_{o1}$

### Auxiliary Functions

#### i Inhibit for Remote On and Off

**Note:** With open i input: Output is disabled ( $U_o = \text{off}$ ).

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*.

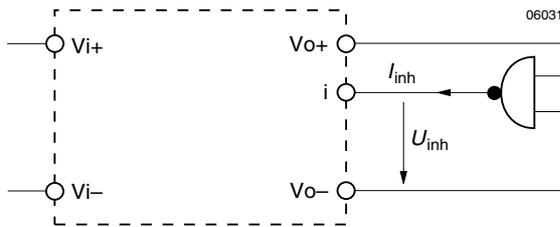


Fig. 13  
Definition of  $U_{inh}$  and  $I_{inh}$ .

Table 5: Inhibit characteristics

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

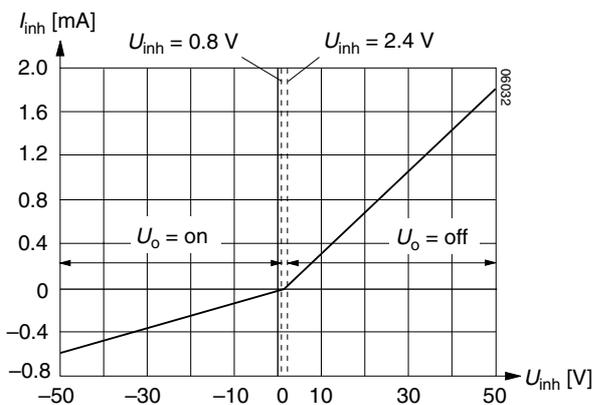


Fig. 14  
Typical inhibit current  $I_{inh}$  versus inhibit voltage  $U_{inh}$

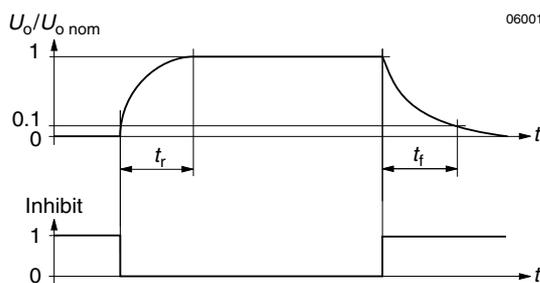


Fig. 15  
Typical output response as a function of inhibit control

#### 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  $U_{o \text{ max}}$  (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  $U_{o \text{ nom}}$  via R-input control, option P setting, remote sensing or option T, the output currents must be reduced accordingly so that  $P_{o \text{ nom}}$  is not exceeded.

**Note:** 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.



R-Function for Different Output Configurations

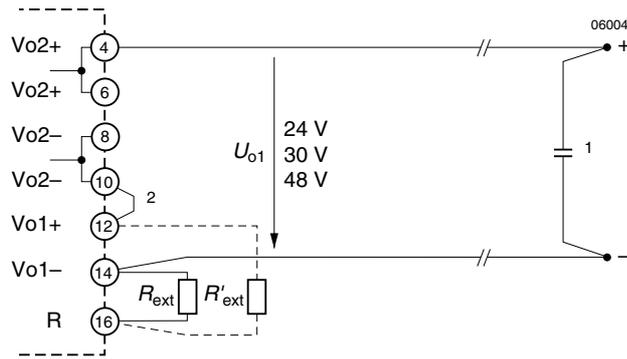


Fig. 17a  
AK...EK 2000 with H15 connector. R-input for output voltage control. Wiring for output voltage 24 V or 30 V or 48 V with main and second output connected in series.

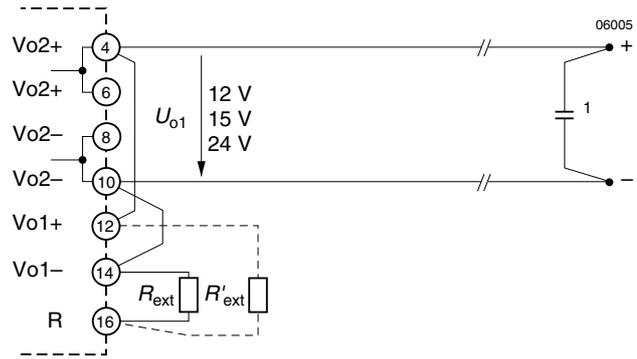


Fig. 17b  
AK...EK 2000 with H15 connector. R-input for output voltage control. Wiring for output voltage 12 V or 15 V or 24 V with main and second output connected in parallel.

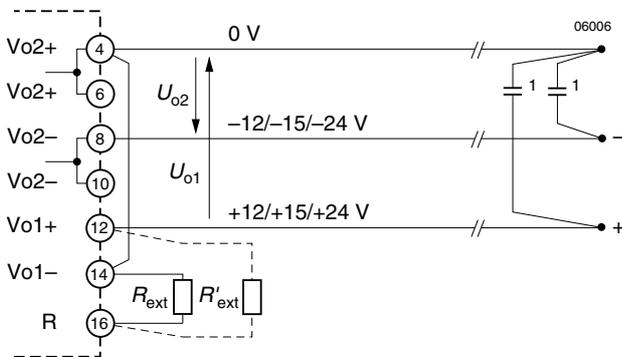


Fig. 17c  
AK...EK 2000 with H15 connector. R-input for output voltage control. Wiring of main and second output for two symmetrical output voltages  $U_{o1}$  and  $U_{o2}$ :  $\pm 12$  V or  $\pm 15$  V or  $\pm 24$  V.

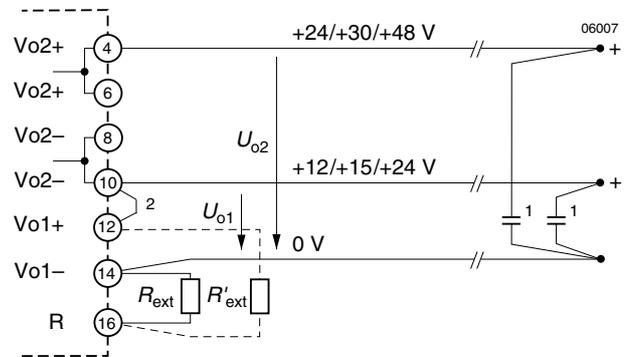


Fig. 17d  
AK...EK 2000 with H15 connector. R-input for output voltage control. Wiring of main and second output for two output voltages  $U_{o1}$  and  $U_{o2}$ : +12 V and +24 V or +15 V and +30 V or +24 V and +48 V.

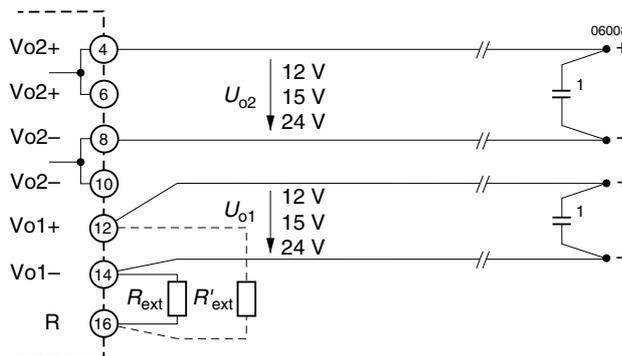


Fig. 17e  
AK...EK 2000 with H15 connector. R-input for output voltage control. Wiring of main and second output for two output voltages  $U_{o1}$  and  $U_{o2}$ : 12 V/12 V or 15 V/15 V or 24 V/24 V, the outputs are galvanically isolated.

- 1 A ceramic multilayer capacitor connected across the output lines reduces ripple and spikes.
- 2 Shortest possible wiring for series connection at the female connector

Remarks:

Double output units fitted with H-15 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

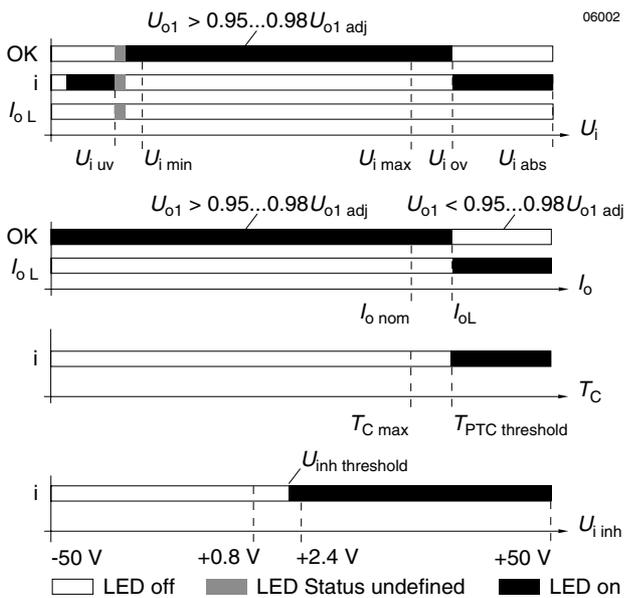


Fig. 18

LEDs "OK", "i" and "I<sub>oL</sub>" status versus input voltage

Conditions: I<sub>o</sub> ≤ I<sub>o nom</sub>, T<sub>C</sub> ≤ T<sub>C max</sub>, U<sub>inh</sub> ≤ 0.8 V

U<sub>i uv</sub> = undervoltage lock-out, U<sub>i ov</sub> = overvoltage lock-out

LEDs "OK" and "I<sub>oL</sub>" status versus output current

Conditions: U<sub>i min</sub>...U<sub>i max</sub>, T<sub>C</sub> ≤ T<sub>C max</sub>, U<sub>inh</sub> ≤ 0.8 V

LED "i" versus case temperature

Conditions: U<sub>i min</sub>...U<sub>i max</sub>, I<sub>o</sub> ≤ I<sub>o nom</sub>, U<sub>inh</sub> ≤ 0.8 V

LED "i" versus U<sub>inh</sub>

Conditions: U<sub>i min</sub>...U<sub>i max</sub>, I<sub>o</sub> ≤ I<sub>o nom</sub>, T<sub>C</sub> ≤ T<sub>C max</sub>

Test Sockets (Main output only)

Test sockets for measuring the output voltage U<sub>o1</sub> 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<sub>o</sub> = 24 V, 30 V or 48 V the monitored output voltage is 12 V, 15 V or 24 V respectively.

## Electromagnetic Compatibility (EMC)

A suppressor diode or a metal oxide VDR (depending upon the type) together with an input fuse and an input filter form an effective protection against high input transient voltages

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

### Electromagnetic Immunity

Table 8: Immunity type tests

Phenomenon	Standard <sup>1</sup>	Level	Coupling mode <sup>2</sup>	Value applied	Waveform	Source imped.	Test procedure	In oper.	Per-form. <sup>3</sup>
Voltage surge	IEC 60571-1		i/c, +i/-i	800 V <sub>p</sub>	100 μs	100 Ω	1 pos. and 1 neg. voltage surge per coupling mode	yes	A
				1500 V <sub>p</sub>	50 μs				
				3000 V <sub>p</sub>	5 μs				
				4000 V <sub>p</sub>	1 μs				
				7000 V <sub>p</sub>	100 ns				
Supply related surge	RIA 12	A <sup>4</sup>	+i/-i	3.5 • U <sub>batt</sub>	2/20/2 ms	0.2 Ω	1 positive surge	yes	A
		B		1.5 • U <sub>batt</sub>	0.1/1/0.1 s				
Direct transient		C	+i/c, -i/c	960 V <sub>p</sub>	10/100 μs	5 Ω	5 pos. and 5 neg. impulses	yes	B
		D		1800 V <sub>p</sub>	5/50 μs				
		E		3600 V <sub>p</sub>	0.5/5 μs	100 Ω			
		F		4800 V <sub>p</sub>	0.1/1 μs				
		G		8400 V <sub>p</sub>	0.05/0.1 μs				
Indirect coupled transient		H	+o/c, -o/c,	1800 V <sub>p</sub>	5/50 μs				5
		J		3600 V <sub>p</sub>	0.5/5 μs				
		K		4800 V <sub>p</sub>	0.1/1 μs				
		L		8400 V <sub>p</sub>	0.05/0.1 μs				
Electrostatic discharge (to case)	IEC/EN 61000-4-2	4	contact discharge	8000 V <sub>p</sub>	1/50 ns	330 Ω	10 positive and 10 negative discharges	yes	A
			air discharge	15000 V <sub>p</sub>					
Electromagnetic field	IEC/EN 61000-4-3	3	antenna	20 V/m	AM 80% 1 kHz	n.a.	80...1000 MHz	yes	A
Electromagnetic field, pulse modulated	ENV 50204			10 V/m	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 <sub>p</sub>	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/o, +i/-i direct	4000 V <sub>p</sub>					
Surge	IEC/EN 61000-4-5	3	i/c	2000 V <sub>p</sub>	1.2/50 μs	12 Ω	5 pos. and 5 neg. surges per coupling mode	yes	A
		4	+i/-i			2 Ω			
Conducted disturbances	IEC/EN 61000-4-6	3	i, o, signal wires	10 V <sub>rms</sub> (140 dBμV)	AM 80% 1 kHz	150 Ω	0.15...80 MHz	yes	A

<sup>1</sup> Related and previous standards are referenced in: *Technical Information: Standards*.

<sup>2</sup> i = input, o = output, c = case.

<sup>3</sup> A = Normal operation, no deviation from specifications, B = Normal operation, temporary deviation from specs possible.

<sup>4</sup> Only met with extended input voltage range of CK (48 V battery) and EK (110 V battery) types. These units are available on customer's request. Standard DK units (110 V battery) will not be damaged, but overvoltage lock-out will occur during the surge. Under normal operation temporary deviation from specifications possible.

<sup>5</sup> Test in progress, please consult factory.

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

Electromagnetic Emission

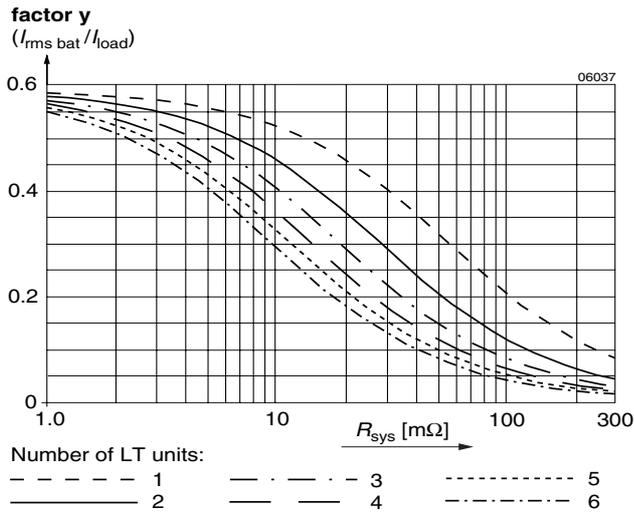


Fig. 19  
Typical disturbance voltage (quasi-peak) at the input according to CISPR 11/22 and EN 55011/22, measured at  $U_{i\ nom}$  and  $I_{o\ nom}$ .

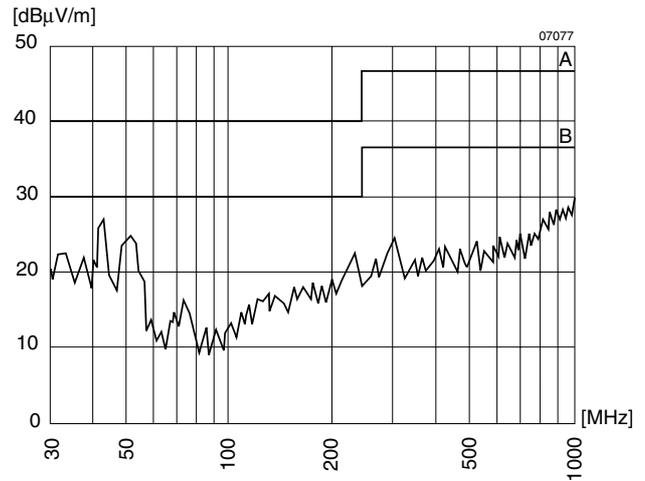


Fig. 20  
Typical radiated electromagnetic field strength (quasi-peak) according to CISPR 11/22 and EN 55011/22, normalized to a distance of 10 m, measured at  $U_{i\ nom}$  and  $I_{o\ nom}$ .

## 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 ±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 <sub>n</sub> = 981 m/s <sup>2</sup> 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 <sub>n</sub> = 392 m/s <sup>2</sup> 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 <sub>n</sub> = 49 m/s <sup>2</sup> (60...2000 Hz) 10...2000 Hz 7.5 h (2.5 h each axis)	Unit operating
Fn	Vibration broad band random (digital control)	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 <sub>n</sub> <sup>2</sup> /Hz 5...500 Hz 4.97 g <sub>n rms</sub> 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, valid for an air pressure of 800...1200 hPa (800...1200 mbar)

Temperature		Standard -7		Option -9		Unit	
Characteristics	Conditions	min	max	min	max		
T <sub>A</sub>	Ambient temperature <sup>1</sup>	Operational <sup>2</sup>	-25	71	-40	71	°C
T <sub>C</sub>	Case temperature <sup>3</sup>		-25	95	-40	95	
T <sub>S</sub>	Storage temperature <sup>1</sup>	Non operational	-40	100	-55	100	

<sup>1</sup> MIL-STD-810D section 501.2 and 502.2.

<sup>2</sup> See: *Thermal Considerations*.

<sup>3</sup> Overtemperature lock-out at T<sub>C</sub> >95 °C (PTC).

Table 11: MTBF

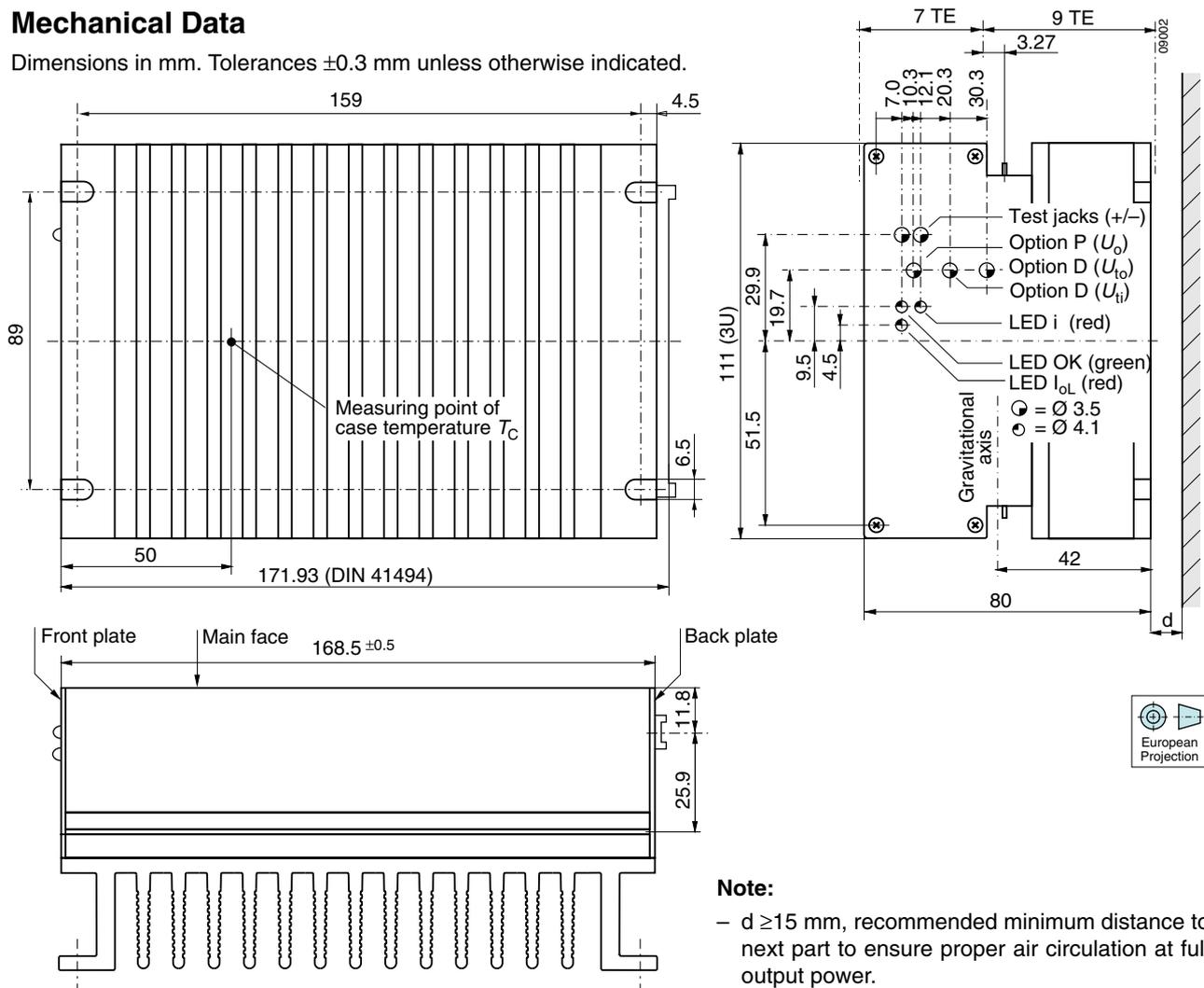
Values at specified case temperature	Module types	Ground benign	Ground fixed		Ground mobile	Unit
		40 °C	40 °C	70 °C	50 °C	
MTBF <sup>1</sup>	AK...EK	500'000	150'000	80'000	50'000	h
Device hours <sup>2</sup>		500'000				

<sup>1</sup> Calculated in accordance with MIL-HDBK-217F.

<sup>2</sup> Statistical values, based on an average of 4300 working hours per year and in general field use, over 3 years.

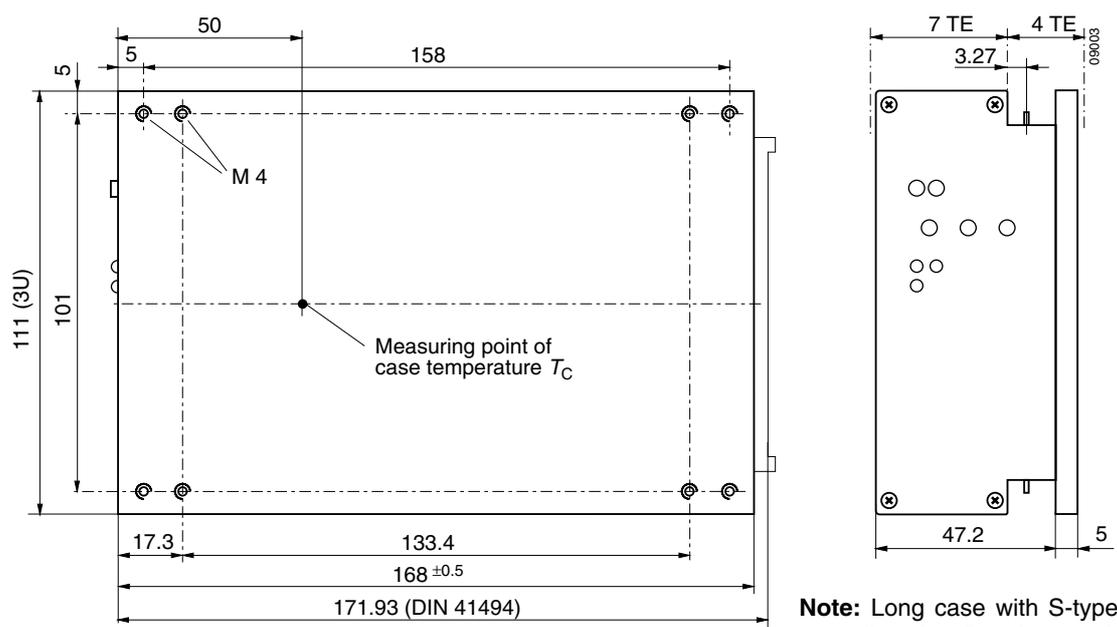
**Mechanical Data**

Dimensions in mm. Tolerances  $\pm 0.3$  mm unless otherwise indicated.



**Fig. 21**  
Case K02 with heatsink, case aluminium, black finish and self cooling, weight: Approx. 1.55 kg

- Note:**
- $d \geq 15$  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. 22**  
Case K02 with option B1 (cooling plate), case aluminium, black finish and self cooling, weight: Approx. 1.15 kg

**Note:** Long case with S-type heatsink or cooling plate B2, elongated by 60 mm for 220 mm rack depth, is available on request. (No LED's and no test jacks.)

## Safety and Installation Instructions

### Connector Pin Allocation

The connector pin allocation table defines the electrical potentials and the physical pin positions on the H15/H15 S4 connector. Pin no. 24, the protective earth pin present on all

AK...FK DC-DC converters is leading, ensuring that it makes contact with the female connector first.



Fig. 23  
View of module's male connectors

Table 12: H15 and H15 S4 connector pin allocation

Pin No.	Connector type H15 S4				Connector type H 15			
	AK 1000 (all), BK...EK 1001		AK 2000		BK...EK 1301/1501/1601		BK...EK 2000	
4	Vo1+	Output 1	Vo2+	Output 2	Vo1+	Output 1	Vo2+	Output 2
6					Vo1+		Vo2+	
8	Vo1-	Output 1	Vo2-	Output 2	Vo1-	Output 1	Vo2-	Output 2
10					Vo1-		Vo2-	
12	S+	Sense	Vo1+	Output 1	S+	Sense	Vo1+	Output 1
14	S-	Sense	Vo1-	Output 1	S-	Sense	Vo1-	Output 1
16	R <sup>1</sup>	Control of U <sub>o1</sub>	R <sup>1</sup>	Control of U <sub>o1</sub>	R <sup>1</sup>	Control of U <sub>o1</sub>	R <sup>1</sup>	Control of U <sub>o1</sub>
18	i	Inhibit	i	Inhibit	i	Inhibit	i	Inhibit
20	D <sup>3</sup>	Save data	D	Safe data	D	Save data	D	Save data
	V <sup>3</sup>	ACFAIL						
22	T	Current sharing	T	Current sharing	T	Current sharing	T	Current sharing
24 <sup>2</sup>	⊕	Protective earth	⊕	Protective earth	⊕	Protective earth	⊕	Protective earth
26	Vi+	Input	Vi+	Input	Vi+	Input	Vi+	Input or Neutral
28					Vi+		Vi+	
30	Vi-	Input	Vi-	Input	Vi-	Input	Vi-	Input or Phase
32					Vi-		Vi-	

<sup>1</sup> Feature R excludes option P and vice versa; <sup>2</sup> Leading pin (pregrounding); <sup>3</sup> Option D excludes option V and vice versa.

### Installation Instructions

The K series DC-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 DC-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 unless specified in: *Safety of operator accessible output circuit*.

An input fuse is built-in in the connection from pins no. 30 and 32 (Vi-) 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 AK...FK 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 possible 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  $T_{C \text{ max}}$  shall not be exceeded. See also *Thermal Considerations*.

If the end-product is to be UL certified, the temperature of the main isolation transformer should be evaluated as part of the end-product investigation.

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.

### 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.

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	AK, BK	1.0	2.0 <sup>1</sup>	0.5	-	kV <sub>rms</sub>	
			1.4	2.8 <sup>1</sup>	0.7	-	kV DC	
		CK, DK EK, FK	1.5	3.0 <sup>1</sup>	0.5	-	kV <sub>rms</sub>	
			2.1	4.2 <sup>1</sup>	0.7	-	kV DC	
	Actual factory test 1 s		AK, BK	2.8	5.6 <sup>1</sup>	1.4	0.14	
	AC test voltage equivalent to actual factory test		CK, DK EK, FK	2.0	4.0 <sup>1</sup>	1.0	0.1	kV <sub>rms</sub>
Insulation resistance at 500 V DC			>300	>300	>300	>100 <sup>2</sup>	MΩ	

<sup>1</sup> In accordance with IEC/EN 60950 only subassemblies are tested in factory with this voltage.

<sup>2</sup> Tested at 150 V DC.

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

### Standards and approvals

All DC-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 and double or reinforced insulation between input and output, based on 150 V AC/DC (AK and BK) or 250 V AC and 400 V DC (CK, DK, EK, FK),
- The use in a pollution degree 2 environment,
- Connecting the input to a primary or secondary circuit which is subject to a maximum transient rating of 2500 V.

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

### 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.

**Safety of operator accessible output circuit**

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

The following table shows some possible installation configurations, compliance with which causes the output circuit of the DC-DC converter to be an SELV circuit according to

IEC/EN 60950 up to a configured output voltage (sum of nominal voltages if in series or +/- configuration) of 35 V.

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

Table 14: Safety concept leading to an SELV output circuit

Conditions	Front end			DC-DC converter		Result
	Minimum required grade of isolation, to be provided by the AC-DC front end, including mains supplied battery charger	Nominal DC output voltage from the front end	Minimum required safety status of the front end output circuit	Types	Measures to achieve the specified safety status of the output circuit	
Mains ≤150 V AC	Operational (i.e. there is no need for electrical isolation between the mains supply voltage and the DC-DC converter input voltage)	≤100 V (The nominal voltage between any input pin and earth can be up to 150 V AC or DC)	Primary circuit	AK BK	Double or reinforced insulation, based on the mains voltage and <sup>2</sup> (provided by the DC-DC converter) and earthed case <sup>3</sup>	SELV circuit
Mains ≤250 V AC		≤400 V (The nominal voltage between any input pin and earth can be up to 250 V AC or 400 V DC)		CK DK EK FK		
	Basic	≤400 V	Unearthed hazardous voltage secondary circuit	AK BK CK DK EK FK	Supplementary insulation, based on 250 V AC and double or reinforced insulation <sup>2</sup> (provided by DC-DC converter) and earthed case <sup>3</sup> .	
			Earthed hazardous voltage secondary circuit		Double or reinforced insulation <sup>2</sup> (provided by the DC-DC converter) earthed case <sup>3</sup>	
	Double or reinforced	≤60 V	SELV circuit		Operational insulation (provided by the DC-DC converter) <sup>4</sup>	
			≤120 V		TNV-3 circuit	

<sup>1</sup> The front end output voltage should match the specified input voltage range of the DC-DC converter.

<sup>2</sup> Based on the maximum nominal output voltage from the front end.

<sup>3</sup> The earth connection has to be provided by the installer according to the relevant safety standard, e.g. IEC/EN 60950.

<sup>4</sup> Earthing of the case is recommended, but not mandatory.

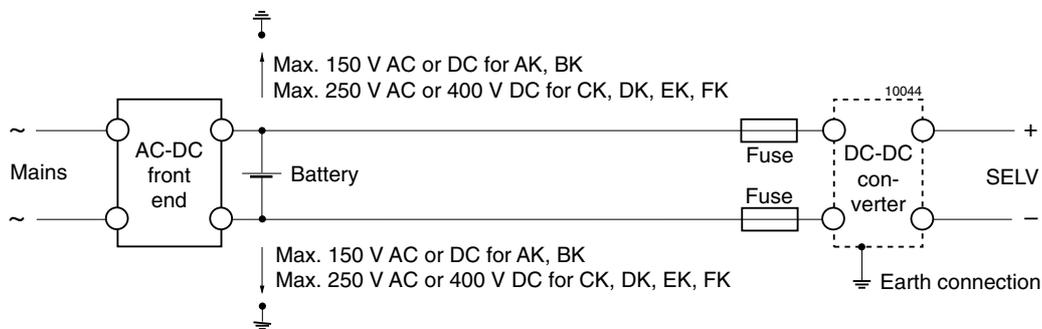


Fig. 24

Schematic safety concept.

Use earth connection as per table: *Safety concept leading to an SELV output circuit*. Use fuse if required by the application. See also: *Installation Instructions*.

### Description of Options

Table 15: Survey of options

Option	Function of Option	Characteristics
-9	Extended operational ambient temperature range	$T_A = -40^{\circ}\text{C} \dots 71^{\circ}\text{C}$
E	Electronic inrush current limitation circuitry	Active inrush current limitation for CK, DK, EK
P <sup>1</sup>	Potentiometer for fine adjustment of output voltage	Adjustment range +10/-60% of $U_{o\text{ nom}}$ excludes R input
D <sup>2</sup>	Input and/or output undervoltage monitoring circuitry	Safe data signal output (Versions D0...DD)
V <sup>2,3</sup>	Input (and output) undervoltage monitoring circuitry	ACFAIL signal according to VME specs (Versions 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

<sup>1</sup> Function R excludes option P and vice versa.

<sup>2</sup> Option D excludes Option V and vice versa

<sup>3</sup> Only available if main output voltage  $U_{o1} = 5.1$ .

#### -9 Extended Temperature Range

Option -9 extends the operational ambient temperature range from  $-25 \dots 71^{\circ}\text{C}$  (standard) to  $-40 \dots 71^{\circ}\text{C}$ . The power supplies provide full nominal output power with convection cooling. Option -9 excludes inrush current limitation by NTC.

#### E Inrush Current Limitation

CK/DK/EK types may be supplemented by an electronic circuit (option E, replacing the standard built-in NTC) to achieve an enhanced inrush current limiting function (not available with AK/BK/FK types).

If fitted with option E (inrush current limitation) together with option D6, input voltage monitoring, the CK units meet the CEPT/ETSI standards for 48 V DC supply voltages according to prETS 300132-2, version 4.2, date 9312. Option D6, externally adjustable via potentiometer, is necessary to disable the converter at input voltages below actual service voltage ranges, avoiding an excessive input current when the input voltage is raised slowly according to prETS 300132-2. Option D6 threshold level should be adjusted to 36.0...40.5 V for 48 V nominal supply systems or 44.0...50.0 V for 60 V nominal supply systems (refer also to description of option D). The D output should be connected to the inhibit input. Please contact Power-One if applications do not permit potentiometer setting.

Table 16: Inrush current characteristics with option E

Characteristics		CK	DK	EK	Unit
$U_{i\text{ nom}}, I_{o\text{ nom}}$	Input voltage	60	110	220	V
$I_{i\text{ nr p}}$	Peak inrush current	6.8	7.4	14.6	A
$t_{i\text{ nr}}$	Inrush current duration	18	14	16	ms
$U_{i\text{ max}}, I_{o\text{ nom}}$	Input voltage	140	220	380	V
$I_{i\text{ nr p}}$	Peak inrush current	9.3	14.5	25.3	A
$t_{i\text{ nr}}$	Inrush current duration	20	14	12	ms

**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 ( $T_C = 95^{\circ}\text{C}$ ) max. 1 cycle every 8 sec.

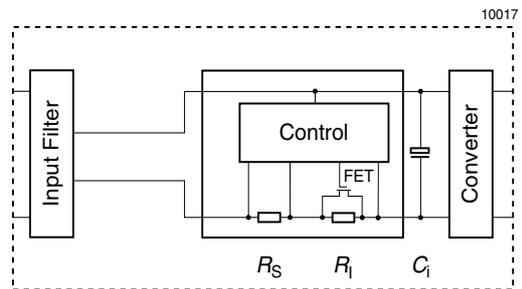
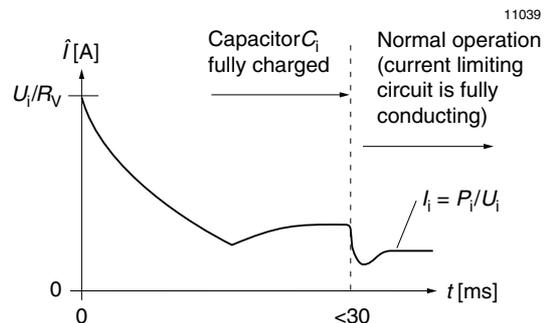


Fig. 25 Option E block diagram



$R_V$ : Current limiting resistance =  $R_S + R_I = 15 \Omega$

Fig. 26 Inrush current with option E

#### P Potentiometer

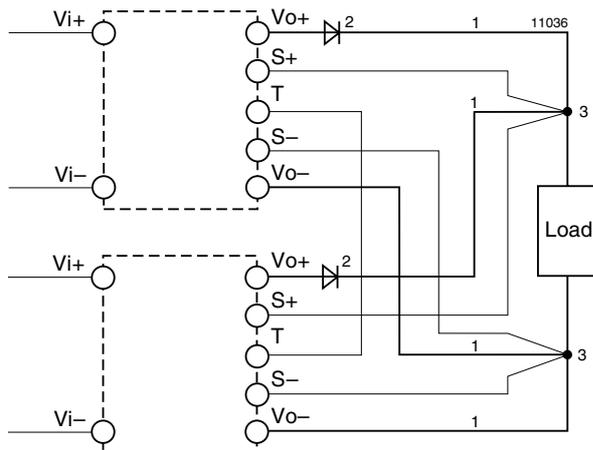
The potentiometer provides an output voltage adjustment range of +10/-60% of  $U_{o\text{ nom}}$  and is accessible through a hole in the front cover. This feature enables compensation of voltage drops across the connector and wiring. Option P is not recommended if units are connected in parallel.

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

**T Current Sharing**

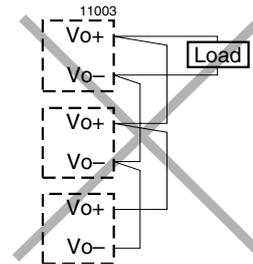
This option ensures that the output currents are approximately shared between all paralleled modules hence increasing system reliability. To use this facility, simply interconnect the T pins of all modules and make sure, that pins 14, the S- pins (K 1000) or the Vo1- pins (K 2000) are also connected 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.



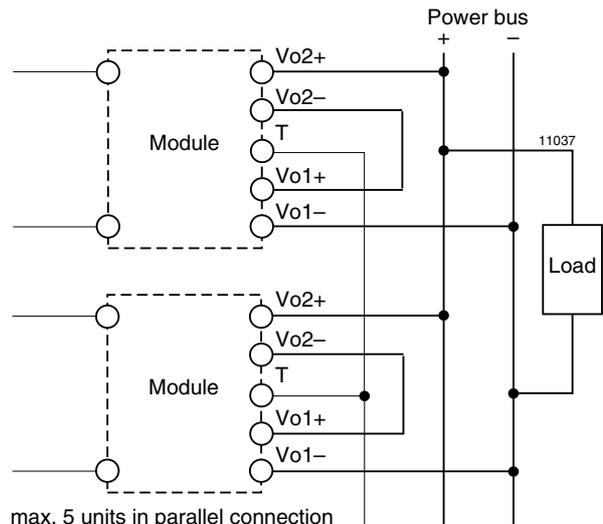
max. 5 units in parallel connection

- <sup>1</sup> Leads should have equal length and cross sections and should run in the same cable loom.
- <sup>2</sup> Diodes recommended in redundant operation only
- <sup>3</sup> DC common point

*Fig. 28  
Paralleling of single output units using option T with the sense lines connected at the load*



*Fig. 27  
An example of poor wiring for connection in parallel*



max. 5 units in parallel connection

*Fig. 29  
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 lock-out 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 levels  $U_{ti}$  and  $U_{to}$  are either adjustable 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 17: Undervoltage monitor functions

Output type		Monitoring		Minimum adjustment range of threshold level $U_t$		Typical hysteresis $U_h$ [% of $U_t$ ] for $U_{t\ min} \dots U_{t\ max}$	
JFET	NPN	$U_i$	$U_{o1}$	$U_{ti}$	$U_{to}$	$U_{hi}$	$U_{ho}$
D1	D5	no	yes	-	$3.5 \dots 40\ V^1$	-	$2.5 \dots 0.6$
D2	D6	yes	no	$U_{i\ min} \dots U_{i\ max}^1$	-	$3.4 \dots 0.4$	-
D3	D7	yes	yes	$U_{i\ min} \dots U_{i\ max}^1$	$(0.95 \dots 0.985\ U_{o1})^2$	$3.4 \dots 0.4$	"0"
D4	D8	no	yes	-	$(0.95 \dots 0.985\ U_{o1})^2$	-	"0"
D0	D9	no	yes	-	$3.5 \dots 40\ V^3$	-	$2.5 \dots 0.6$
		yes	no	$U_{i\ min} \dots U_{i\ max}^{3\ 4}$	-	$3.4 \dots 0.4$	-
		yes	yes	$U_{i\ min} \dots U_{i\ max}^{3\ 4}$	$3.5 \dots 40\ V^3$	$3.4 \dots 0.4$	$2.5 \dots 0.6$
		yes	yes	$U_{i\ min} \dots U_{i\ max}^{3\ 4}$	$(0.95 \dots 0.985\ U_{o1})^2$	$3.4 \dots 0.4$	"0"
-	DD	yes	yes	$U_{i\ min} \dots U_{i\ max}^1$	$3.5 \dots 40\ V^1$	$3.4 \dots 0.4$	$2.5 \dots 0.6$

<sup>1</sup> Threshold level adjustable by potentiometer

<sup>2</sup> Fixed value tracking if  $U_{o1}$  is adjusted via R-input, option P or sense lines.

<sup>3</sup> The threshold level permanently adjusted according to customer specification  $\pm 2\%$  at  $25^\circ C$ . Any value within the specified range is basically possible but causes a special type designation in addition to the standard option designations (D0/D9 respectively)!

<sup>4</sup> Adjusted at  $I_{o\ nom}$

**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, $I_D \leq 25\ \mu A$ at $U_D = 5.25\ V$

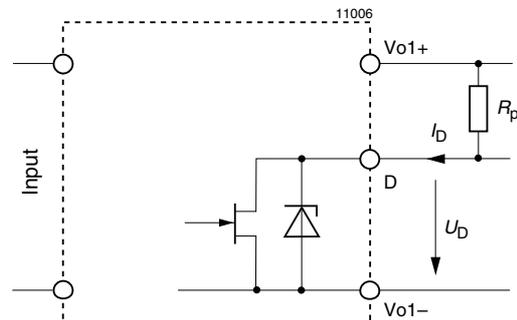


Fig. 30 Option D1...D0: JFET output,  $I_D \leq 2.5\ mA$

**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, $I_D \leq 25\ \mu A$ at $U_D = 40\ V$
$U_i$ and $U_{o1} > U_t + U_h$	low, L, $U_D \leq 0.4\ V$ at $I_D = 20\ mA$

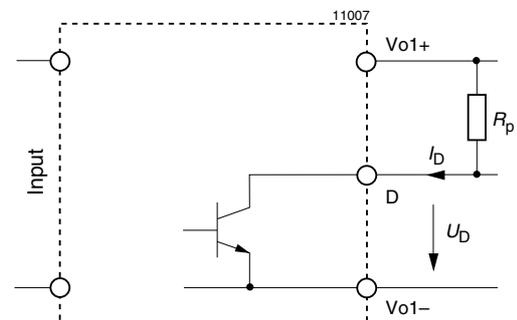


Fig. 31 Option D5...DD: NPN output,  $U_{o1} \leq 40\ V, I_D \leq 20\ mA$

Table 18: 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

Threshold tolerances and hysteresis:

If  $U_i$  is monitored, the internal input voltage after the input filter is measured. Consequently this voltage differs from the voltage at the connector pins by the voltage drop  $\Delta U_{ti}$  across the input filter. The threshold levels of the D0 and D9 options are factory adjusted at nominal output current  $I_{o\ nom}$  and at  $T_A = 25^\circ\text{C}$ . The value of  $\Delta U_{ti}$  depends upon the input voltage range (CK, DK, ..), threshold level  $U_t$ , temperature and input current. The input current is a function of the input voltage and the output power.

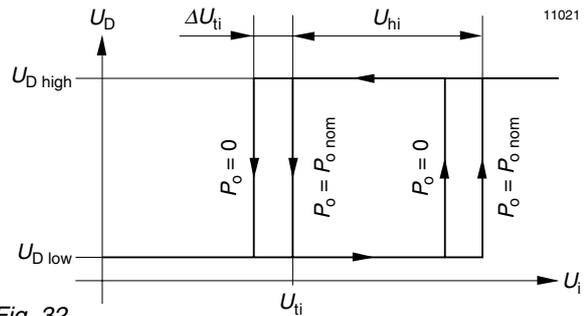
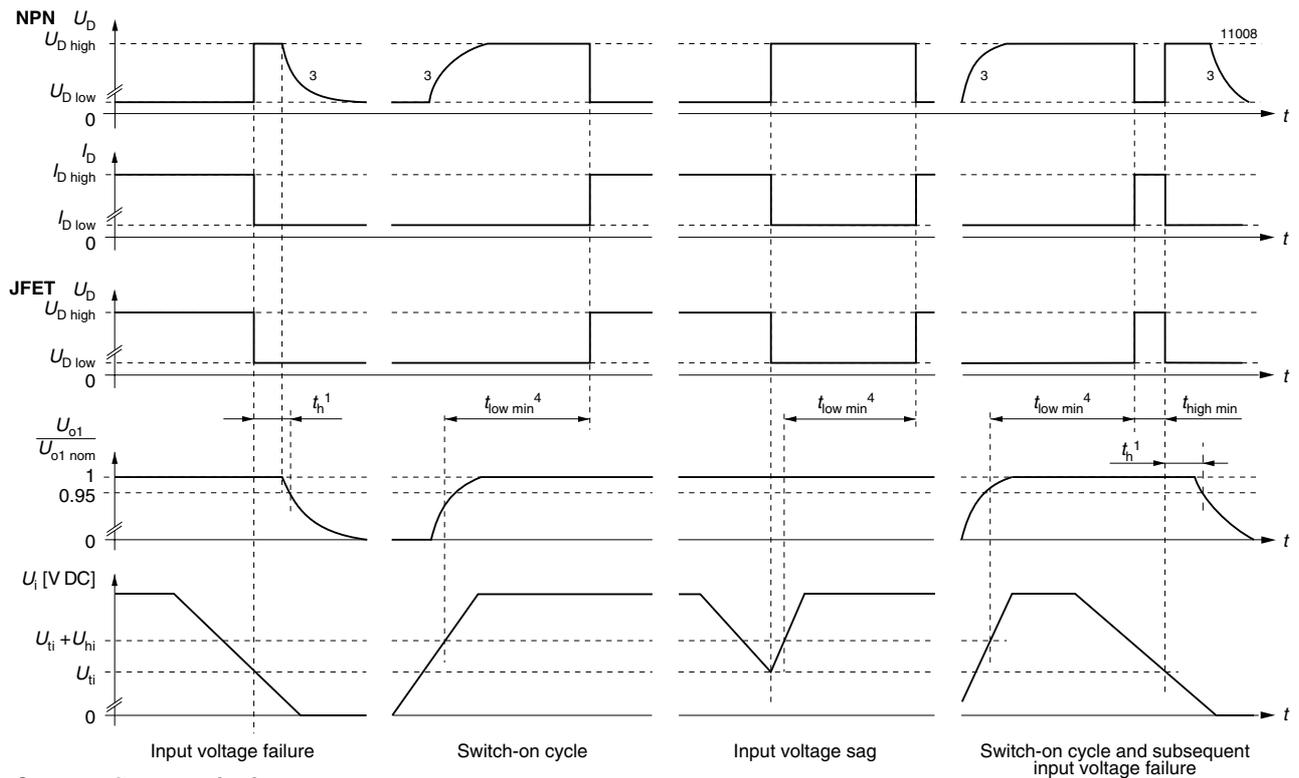


Fig. 32 Definition of  $U_{ti}$ ,  $\Delta U_{ti}$  and  $\Delta U_{hi}$  (JFET output)

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

Input voltage monitoring



Output voltage monitoring

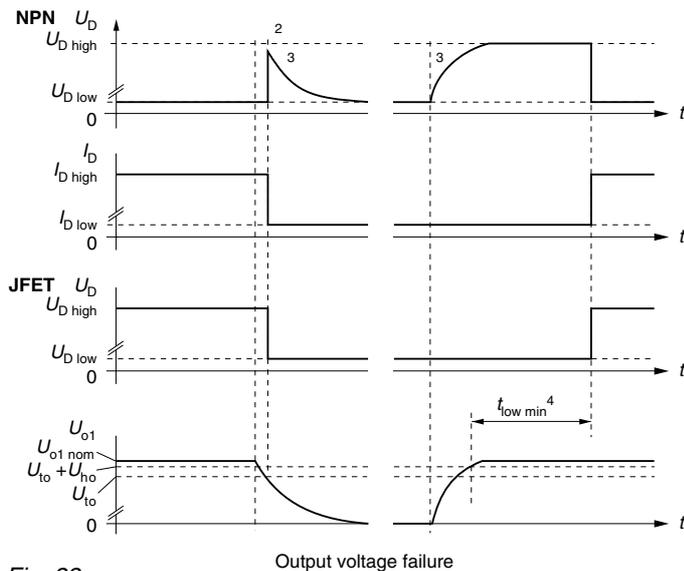


Fig. 33 Relationship between  $U_i$ ,  $U_{o1}$ ,  $U_D$ ,  $U_{o1}/U_{o\ nom}$  versus time

- 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.

**V ACFAIL signal (VME)**

Available for units with  $U_{o1} = 5.1$  V.

This option defines an undervoltage monitoring circuit for the input or input and main output voltage ( $U_{o1\text{ nom}} = 5.1$  V only) equivalent to option D and generates an 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. Consequently the working input voltage and the threshold level  $U_{ti}$  should be adequately above the minimum input voltage  $U_{i\text{ min}}$  of the converter so that enough energy is remaining in the input capacitance. If the input voltage is below the required level, an external hold-up capacitor ( $C_{i\text{ ext}}$ ) should be added.

Formula for threshold level for desired value of  $t_h$ :

$$U_{ti} = \sqrt{\frac{2 \cdot P_o \cdot (t_h + 0.3 \text{ ms}) \cdot 100}{C_{i\text{ min}} \cdot \eta}} + U_{i\text{ min}}^2$$

Table 19: Available internal input capacitance and factory potentiometer setting of  $U_{ti}$  with resulting hold-up time

Types	AK	BK	FK	CK	DK	EK	Unit
$C_{i\text{ min}}$	0.83	0.3	1.2	0.66	0.26	0.21	mF
$U_{ti}$	9.5	19.5	39	39	61	97	V DC
$t_h$	0.1	0.1	3.4	1.1	1.1	2.7	ms

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

Formula for the external input capacitor:

$$C_{i\text{ ext}} = \frac{2 \cdot P_o \cdot (t_h + 0.3 \text{ ms}) \cdot 100}{\eta \cdot (U_{ti}^2 - U_{i\text{ min}}^2)} - C_{i\text{ min}}$$

where as:

- $C_{i\text{ min}}$  = internal input capacitance [mF]
- $C_{i\text{ ext}}$  = external input capacitance [mF]
- $P_o$  = output power [W]
- $\eta$  = efficiency [%]
- $t_h$  = hold-up time [ms]
- $U_{i\text{ min}}$  = minimum input voltage [V]<sup>1</sup>
- $U_{ti}$  = threshold level [V]

<sup>1</sup> Min. input voltage according to *Electrical Input Data*. For output voltages  $U_o > U_{o\text{ nom}}$ , the minimum input voltage increases proportionally to  $U_o/U_{o\text{ nom}}$ .

Remarks:

Option V2 and V3 can be adjusted by potentiometer to a threshold level between  $U_{i\text{ min}}$  and  $U_{i\text{ max}}$ . A decoupling diode should be connected in series with the input of AK...FK converters to avoid the input capacitance discharging through other loads connected to the same source voltage.

Table 20: Undervoltage monitor functions

V output (VME compatible)	Monitoring		Minimum adjustment range of threshold level $U_t$		Typical hysteresis $U_h$ [% of $U_t$ ] for $U_{t\text{ min}} \dots U_{t\text{ max}}$	
	$U_i$	$U_{o1}$	$U_{ti}$	$U_{to}$	$U_{hi}$	$U_{ho}$
V2	yes	no	$U_{i\text{ min}} \dots U_{i\text{ max}}^1$	-	3.4...0.4	-
V3	yes	yes	$U_{i\text{ min}} \dots U_{i\text{ max}}^1$	$0.95 \dots 0.985 U_{o1}^2$	3.4...0.4	"0"
V0	yes	no	$U_{i\text{ min}} \dots U_{i\text{ max}}^{3,4}$	-	3.4...0.4	-
	yes	yes	$U_{i\text{ min}} \dots U_{i\text{ max}}^{3,4}$	$0.95 \dots 0.985 U_{o1}^2$	3.4...0.4	"0"

<sup>1</sup> Threshold level adjustable by potentiometer. <sup>2</sup> Fixed value between 95% and 98.5% of  $U_{o1}$  (tracking). <sup>3</sup> Adjusted at  $I_{o\text{ nom}}$ . <sup>4</sup> Fixed value, resistor-adjusted ( $\pm 2\%$  at 25°C) acc. to customer's specifications; individual type number is determined by Power-One.

V output (V0, 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, $I_V \leq 25$ $\mu$ A at $U_V = 5.1$ V

voltage(s) exceed(s)  $U_t + U_h$ . The threshold level  $U_{ti}$  is either adjustable by potentiometer, accessible through a hole in the front cover, or adjusted during manufacture to a determined customer specified value.

Versions V0, V2 and V3 are available as shown below.

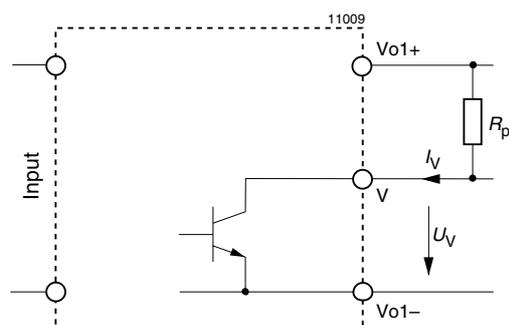


Fig. 34 Output configuration of options V0, V2 and V3

Threshold tolerances and hysteresis:

If  $U_i$  is monitored, the internal input voltage is measured after the input filter. Consequently this voltage differs from the voltage at the connector pins by the voltage drop  $\Delta U_{ti}$  across the input filter. The threshold level of option V0 is adjusted during manufacture at  $I_{o\ nom}$  and  $T_A = 25^\circ\text{C}$ . The value of  $\Delta U_{ti}$  depends upon the input voltage range (AK, BK, ...), threshold level  $U_t$ , temperature and input current. The input current is a function of input voltage and output power.

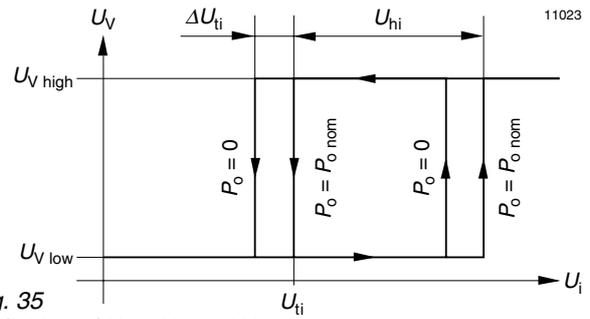


Fig. 35  
Definition of  $U_{ti}$ ,  $\Delta U_{ti}$  and  $U_{hi}$

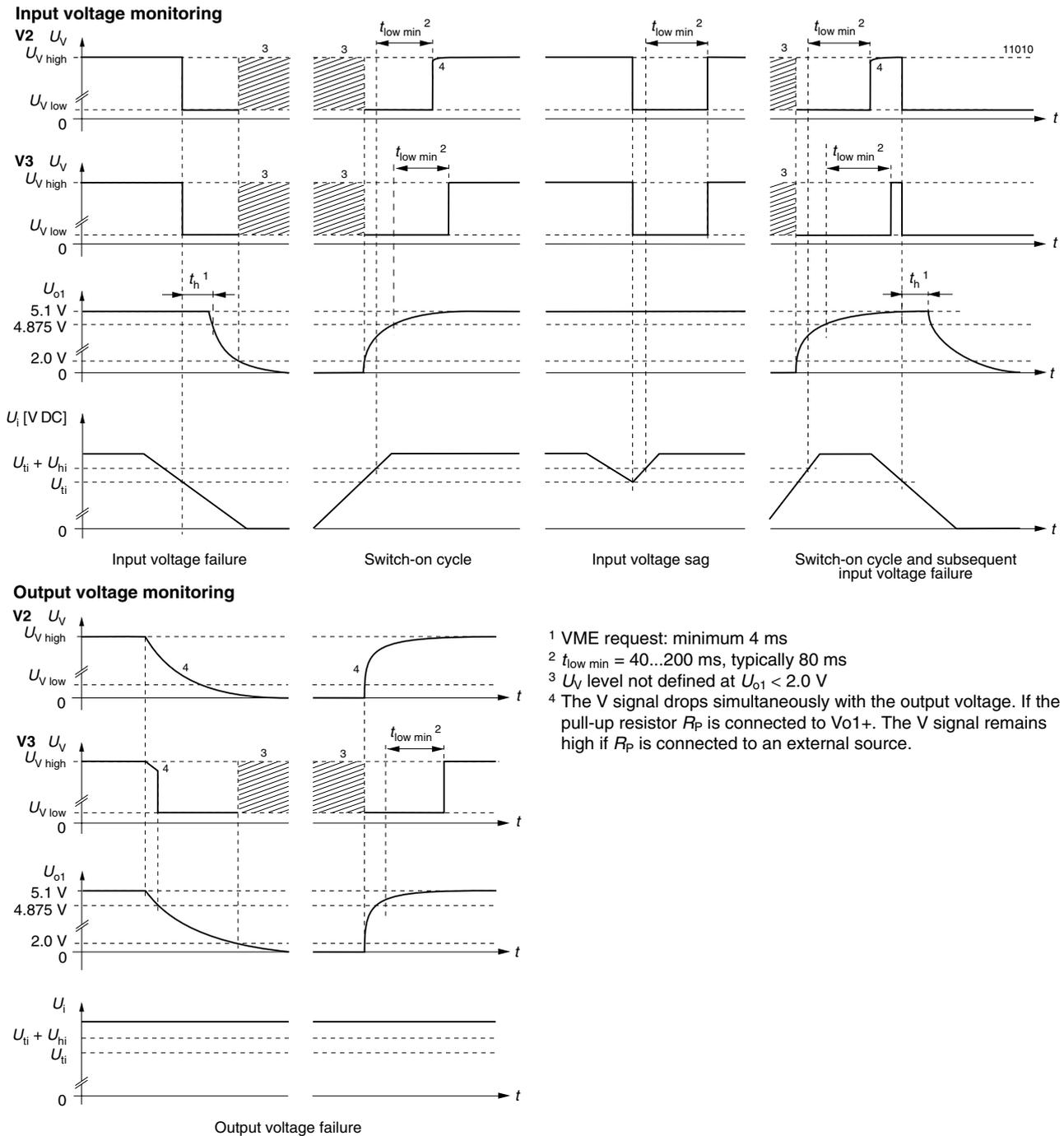


Fig. 36  
Relationship between  $U_i$ ,  $U_{o1}$ ,  $U_V$ ,  $I_V$  and  $U_{o1}/U_{o\ nom}$  versus time.

- 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.

**B1/B2 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:

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

Efficiency  $\eta$  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/H15 S4 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.

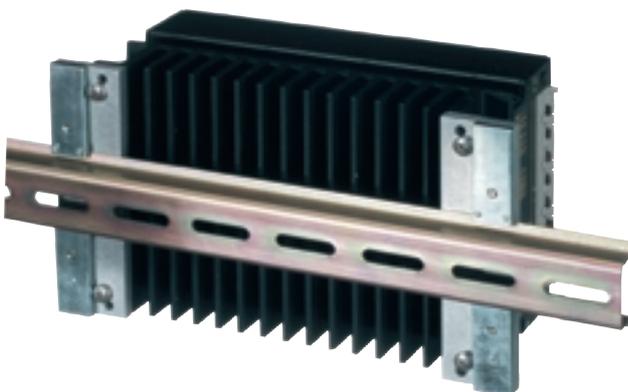
For more detailed information please refer to: *Accessory Products*.



*Front panels*



*H15 female connector, code key system*



*Universal mounting bracket for DIN-rail mounting.*



*Mounting plate (option B1 essential), connector retention clips*